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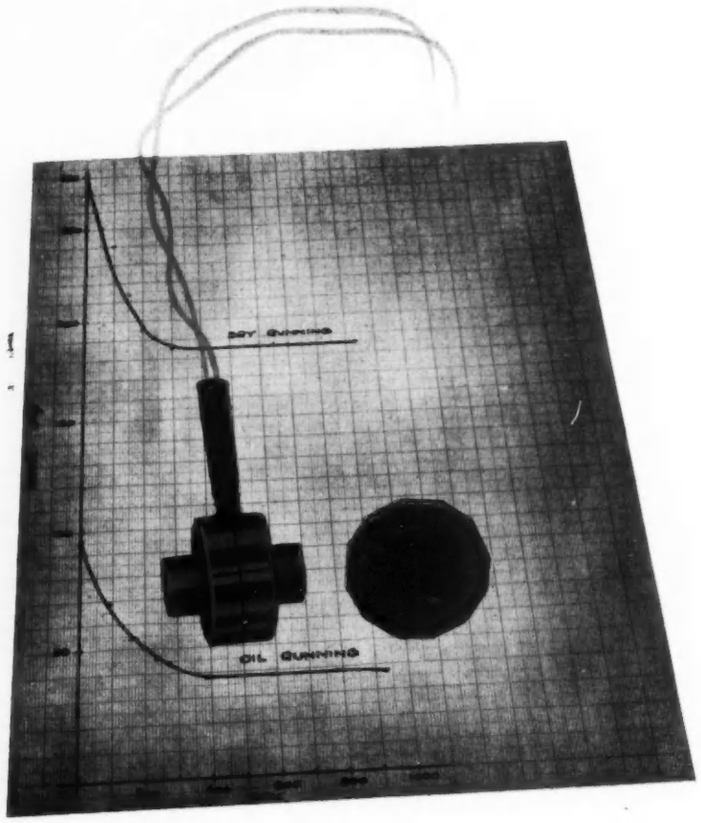

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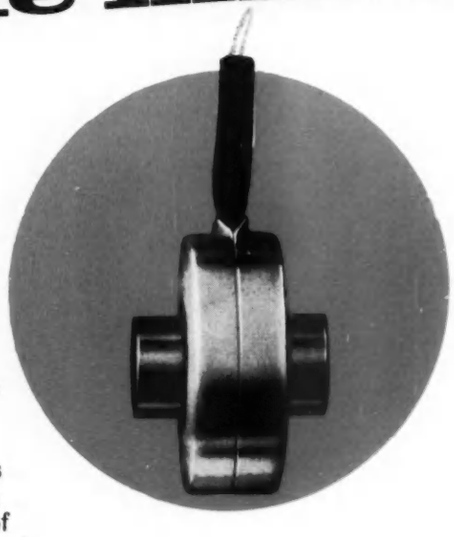

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THE ENGINEER

Established 1856

No. 5503 **JULY 14, 1961** VOL. 212

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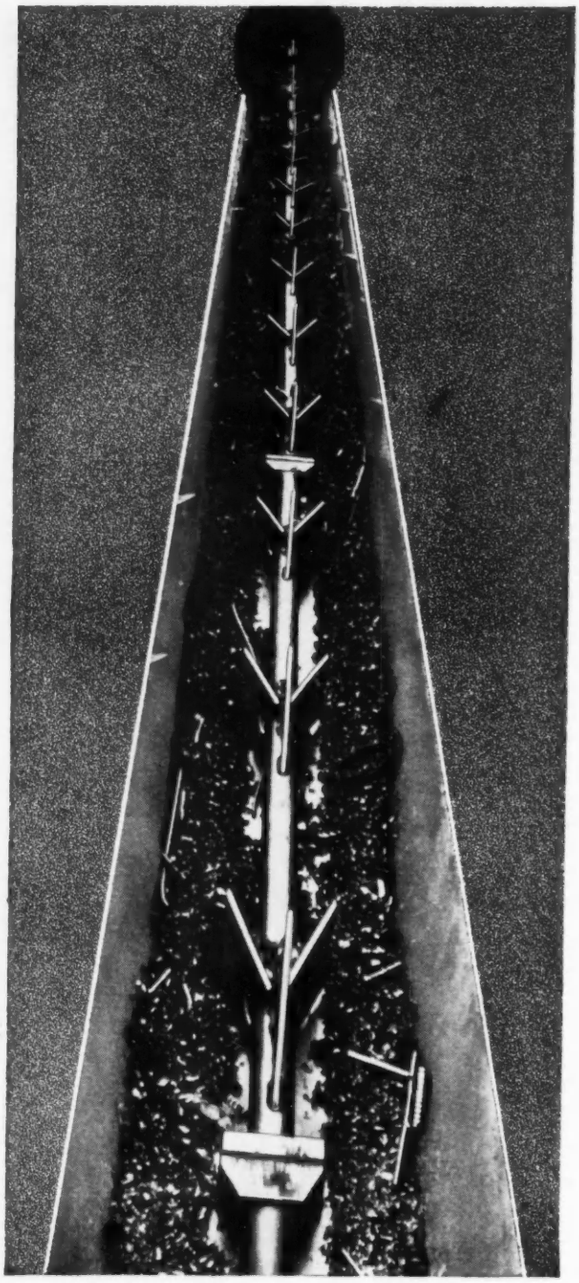

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THE ENGINEER

No. 5503 JULY 14, 1961 Vol. 212

ASSURED FUTURE FOR "BLUE STREAK"

A great many engineers will have been relieved to hear the news last week that the West German Government has expressed in principle its willingness to participate in a European organisation for the development of space vehicle launchers. For months past the fate of the "Blue Streak" rocket, originally developed as a weapon of war, has lain under a cloud. Sensibly, and following suggestions made by this and other journals, the Government decided, when its further development as a weapon was abandoned, to approach European countries to see whether a joint policy of developing rockets for space research might prove attractive and it offered "Blue Streak" as the first stage of a satellite launcher. It was originally contemplated that the British "Black Knight" rocket, which has been repeatedly fired with success at Woomera, might be used as a second stage; but the French, who quickly fell in with the general idea, proposed the use of a French rocket now under development. The resulting project for the international development of rockets for launching space vehicles was jointly put before an international assembly at Strasbourg last February; and since then Western German engineers have been examining it critically and in detail and, it has been reported, not with much enthusiasm.

There was always a doubt in the minds of many engineers as to whether the Germans would wish to participate. For "Blue Streak," which was initially designed as a ballistic missile, is not an ideal rocket to act as a launcher. Nor is it revolutionary in design in any way. Its engines are based on American designs and burn kerosene and liquid oxygen. If and when "Blue Streak" is first fired — presumably from the Woomera range — no advance will have been made in the science and art of rocketry. Rockets of more advanced designs have already been launched in America, and, of course, in Russia. Moreover, it might have proved possible, judging by a tentative offer actually made, to have obtained rockets, more suitable than "Blue Streak" for the launching of satellites, from America. The Germans who can be surmised to have had little taste for contributing little more than the rather simple final stage rocket to the project may have been tempted to have nothing to do with the idea. But certain factors must have swung the balance and though no one can be sure what they were some reasonable guesses can be made. One such factor is likely to have been the argument that if Europeans are to become proficient in rocketry and thereby gain the advantage of being able to apply lessons learnt in rocketry to other technologies, they can do so only by designing and making their own rockets. "Blue Streak" may not be at all advanced in design but it is in being, it is being statically tested and these tests have shown a progressive improvement in reliability, and it will provide an opportunity to learn quickly much more about the control and operation of a satellite launcher. Only by gaining actual launching experience is much knowledge to be gained upon which to found the design of a new generation of more advanced rockets. Additionally it may have been argued that unless the actual design and construction of rockets is done in Europe it will not be possible to retain in Europe the services of talented young engineers interested in rocketry. Indeed, despite arrangements that have been made for British instrumented satellites to be launched in America by American rockets we rather doubt whether some British scientists might not be lost to America were no arrangements in train for launching our own satellites by European designed rockets. For the characteristics of the rocket used to place a satellite in orbit must influence the nature of the equipment which can be accommodated and scientists might feel frustrated by the limits thus imposed upon them.

There is still another important factor to be mentioned which we have little doubt had an influence on German thinking. In the last twelve months it has been becoming more and more certain that rocketry can prove commercially attractive. By setting a number of suitable satellites in orbit numerous channels for telephony and telegraphy around the world could be made available and estimates suggest that despite the high cost of setting up the satellites and of their replacement as and when necessary, the price of transmitting messages should be substantially reduced. The General Post Office in this country has been recently studying the possibilities and on page 65 of this issue a communication from that Department is published. A number of commercial firms in this country are interested. Certain firms have indeed formed a consortium, principally, it may be suspected, to bring pressure to bear on the Government to move forward with or without European co-operation. No doubt French and German firms are

thinking along similar lines; and if there are attractive commercial possibilities there are obvious reasons why European firms should wish not to have to depend on American rockets to put their satellites in orbit! Some notes on the form the international organisation might take are printed on page 65. Engineers interested in rocketry in this country will heave a deep sigh of relief. For even if they might have preferred to develop "Blue Streak" for satellite launching as a purely British endeavour there is now an assurance that there will be a future for work upon space rockets in Europe.

CIVIL ENGINEERING RESEARCH

Last week it was officially announced by the Institution of Civil Engineers that a Civil Engineering Research Council had been set up. An appeal has been opened for funds. Our readers will have known about this development earlier because in presenting the Unwin Memorial Lecture on May 30 Professor Baker (upon whom a knighthood was conferred in the last Honours List) discussed in a part of the lecture which we reproduced, the need for more extensive civil engineering research and revealed that the Council had in fact already been set up jointly by the Institution, the Federation of Civil Engineering Contractors, and the Association of Consulting Engineers on November 22 last year. The project also has the support of the Department of Scientific and Industrial Research which will be represented on the Council and which will follow its usual practice of providing, to begin with, finance approximately equal to that which can be raised by the Council itself. At the time when the announcement was made consulting engineers and contractors had offered contributions totalling more than £20,000 per year, the very minimum with which any really useful work could be done. Very much more is needed and those willing to help should contact the Secretary of the Institution. A preliminary investigation of subjects inviting research suggests that the cost of these investigations alone, without allowing for any extensions of them which might prove necessary, would be £250,000.

There is no present intention to create any new laboratories for civil engineering research, though such a project is not ruled out for the future. The objects of the new Council are well summarised in a pamphlet which has just been issued to aid the appeal for funds. "The Council will receive and consider proposals regarding subjects for research; select those with the strongest claim for immediate attention; ascertain which research establishments are able and willing to undertake the work; allocate funds, and provide the requisite co-ordination. An expert sub-committee will be set up for each project, defining the terms of reference, supervising the research work and preparing the reports. These reports will be circulated to members of the Research Council for comment before publication." The actual researches will be done at the laboratories of appropriate research associations, of which there are several in existence, at the universities and within the industry.

The Council has been at pains in issuing the appeal to remove any impression that research in civil engineering has been neglected in this country. It points out that ever since its foundation the Institution has fostered research and that in 1935 it set up a special Research Committee and provided some funds for the purpose which were augmented by generous contributions from other bodies, especially the D.S.I.R. It is also stressed that a substantial amount of research has been done for many years by civil engineering contractors and by individual firms and industries supplying materials of construction which have set up research associations from whose work civil engineering as a whole has benefited. But the total effort put into research is held to have been inadequate in amount and unevenly directed. We think the majority of engineers will concur in that assessment of the situation. For, though such an annual publication as our own *Tabular Summary of Civil Engineering Contracts* reveals that the amount of work designed by British consulting engineers and constructed by British contractors abroad has expanded and is perhaps still expanding, we think there is also plenty of evidence that engineers and contractors from other countries have benefited from the more extensive and better directed researches carried out in their countries, in reaching out for contracts elsewhere. There was a time in the golden past when hardly any notable structure the wide world over could be built without the help of British engineers; and even within living memory there was a time when hardly any notable civil engineering works were carried out elsewhere than in Europe or the United States without British engineers being at least called in to advise. The situation is far different now and some of that difference may well be accounted for by the greater attention given to research in civil engineering in other countries than Britain. The appeal of the new Research Council for funds ought to be well supported.

SOVIET EXHIBITION AT EARLS COURT

A week ago on Thursday, Earls Court presented the accustomed pre-opening picture of a confused struggle to beat the clock. Twenty-four hours later, the confusion had vanished, the paint and packing cases and dangling wires had been cleared, dismantled, or carefully tucked out of the way — and the Soviet Exhibition was declared open. Not that the path of exhibitions, from Crystal Palace 1851 onwards, ever yet ran smoothly. Alas on that first afternoon, in the section devoted to the "Cosmos", only one film projector out of a promised five was in operation, another stood mutely awaiting its attendant while in the starlit darkness stood spaceship and sputnik, technological mysteries, unprovided with legend or inscription. However, if the primeval state of the "Cosmos" disappointed, most of the rest must be counted an unqualified success, within, of course, its terms of reference which are, to present a picture of economic and cultural life in the U.S.S.R. to-day.

The exhibition certainly is not a trade show in the sense in which the recent British Fair in Moscow was one, although the business aspect is catered for by the provision of information services and the attendance of officials concerned with trade. While in Moscow only the Board of Trade display made any attempt to present a synoptic view of some aspects of life in Great Britain, here the emphasis is reversed. The thing however is done with skill and in moderation. Statistics abound, but do not oppress. An array of polyglot film projectors sketch particular lines of development, amplify what can be seen from models or displays, outline technical innovations, introduce glimpses of town and country and of the people. Attendants are extremely keen and friendly, and many speak surprisingly good English. The layout is well conceived, dividing the

huge and forbidding space and apportioning it and creating a balance of volumes and directions, giving the impression of a harmonious whole.

Whereas the spirit of the Moscow Trade Fair was individualistic, though this was tempered by the urgencies of the occasion, the Soviet show (one is almost tempted to say) in spite of trying for once to be different, again and again reverts to an emphasis of the collective aspects of life. It is a moot point which approach is the more appreciated by visitors. Of the good intentions on the part of those intimately concerned with the two exhibitions there can be no doubt. Let us hope the two events will contribute to that mutual understanding and tolerance of which all of us stand so much in need.

NOISE

A three-day international conference on the control of noise was held recently at the National Physical Laboratory, Teddington. It is a welcome development that so much interest should be shown in this subject by engineers and scientists. For, surprisingly, it has been a rather neglected subject in this country and by British universities — surprisingly because it poses some intriguing and in some respects intractable problems. The subject has the special interest that, more so than in other sciences, the subjective effects of noise prove often to be more important to human beings than the objective reality revealed by some kind of meter. It depends, for example, on the nature of a noise as much as upon its level whether it is objectionable. Tiny noises can be highly irritating — the bluebottle buzzing against the window pane in a quiet office. But a very similar noise can be delightful — the hum of hundreds of bees over a flower bed on a warm and sunny afternoon. The noise of a concrete breaker in the road outside the window can render constructive thought impossible; yet a symphony orchestra can blast one's eardrums just as effectively and yield exquisite pleasure. Some noises please some people and not others. How late teenagers love the exciting roar of certain motor-cycles; how their elders find the same noise excruciating! In studying noise it is, in fact, not sufficient just to measure the sound level instrumentally. Account must be taken of the nature of the sound and the effort must be made to distinguish those elements in any given sound which will prove especially annoying. That is why, of course, speakers at the conference studied not only means and methods of measuring sound, and of evaluating materials for sound insulation and of discovering how sounds can be carried from one place to another, but also the individual problems of reducing the noise emitted by particular mechanisms and machines together with such subjects as the subjective effects of noise on performance and productivity. We look forward to the publication in due course of the whole proceedings at the conference and we hope that engineers in general will study them. For engineers have to admit that nowadays it is predominantly engineering products which are responsible for the majority of the excruciating noises which so often afflict one's ears in streets, in factories, and even in one's home and the countryside.

ASSISTANCE OVERSEAS

Whether they like it or not the under-developed countries of the world have in some ways to pull themselves up by their own bootstraps. Richer countries can lend them the money and build for them power stations and irrigation systems, steel works, roads, railways and harbours and so on. But none of this assistance is of very much avail unless the inhabitants of the countries concerned learn to operate and maintain such plants and later how to design them for themselves and to suit their own conditions. Moreover, it is very desirable that technical advice should be available from the very start so as to prevent credits made available being wasted on plant excellent in itself but of little immediate value to the country concerned. Thus it is as much a major factor in the development of backward countries to provide technical assistance and help with education and training as to provide finance. For this country it is fortunate that it is so. For though Britain is making credits available which are by no means negligible in amount it cannot hope to compete in that field with the United States or even perhaps with the Russians. But this country can and is providing much technical assistance and it can and is providing splendid opportunities for technical education and training. How extensive such work has become was made clear a fortnight ago when amongst eight ministerial appointments announced by the Prime Minister there figured the name of Mr. Dennis Vosper. He is to become Secretary of the new Department of Technical Co-operation which, with a staff of about 1000, is to become responsible for providing and educational assistance overseas. Last week it was further announced that Sir Andrew Cohen has been appointed Director-General of the new Department and thus becomes its permanent official head.

The Engineer—100 Years Ago (JULY 12, 1861)

"The Bayswater-Road Tramway"

"The first street railway in London is ordered to be taken up, and the Uxbridge-road restored to its wonted condition before the 4th of October next. The roads commissioners, notwithstanding the favourable report of their own engineer, and the petition of some thousand persons in behalf of the line, felt constrained to yield to the counter petition of about two thousand of the most influential residents of the neighbourhood. We sympathise with Mr. Train in his disappointment, but the result was to have been expected. With a certain amount of bravado he put down his rails directly under the noses of the wealthy residents of Bayswater, mostly 'carriage people,' who, even if they had no prejudice whatever against tramways, had little occasion to use them—still less in the direction of Notting-hill. The first result of the opening of the line was the attraction of an immense crowd, largely composed of the classes which are the especial horror of all aristocratic neighbourhoods."

"Mr. Train's tramway has not, we think, been condemned for being in any respect less safe, convenient, or suitable for its purpose than any other mode of conveyance." "The order of the roads commissioners was the natural result of the circumstances that the tramway, as laid, was of little service to any portion of the public, and of none whatever to those whom it most incommoded . . ." "Mr. Train, therefore, must bow to his fate, pack up his permanent way, make good the thoroughfare, and be off to where himself and his system are likely to be better appreciated. We trust he will not have to go far."

Machinery at the Royal Show

No. II—(*Concluded from page 18, July 7*)

The Royal Agricultural Society's annual show held last week at Cambridge presented a comprehensive display of machinery and equipment for the agricultural and horticultural industries. The demonstration area, which has been increased this year to 16 acres, has proved to be one of the main attractions at the show.

IN this issue we conclude our review of the Royal Show by referring to just a few of the many developments in agricultural machinery and implements which were to be seen displayed there.

On the eve of the show the International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1, introduced the B–414, a new 40 h.p. tractor, which we illustrate in Fig. 9. The four-cylinder diesel engine which powers the tractor is the BD–154, which has a bore of 3½in, a stroke of 4in, and a cubic capacity of 154 cubic inches. The rated governed engine speed is 2000 r.p.m. and maximum torque of 115 lb per foot is developed at 1300 r.p.m. The transmission has eight speeds forward and two reverse.

Fig. 9—The new McCormick International 40 h.p. diesel tractor

The tractor is fitted with a new hydraulic system, the "Vary-Touch." Mounted on a quadrant situated near to the operator's right hand are two levers, one for raising and lowering the implement into or out of work and for position control, and the other for adjusting the draft. The ratio of the movement of the draft control lever to the movement of the implement in the ground is sufficiently close to allow the operator to make precise adjustments. "Vary-Touch" also provides two rates of flow for the hydraulics. The slow speed of flow, and thus reaction, is at the rate of 2·5 g.p.m. at full governed engine speed, and allows corrections given by draft control to be made rather more smoothly. The alternative fast speed of 6·3 g.p.m. is suitable for the speedy operation of loaders or the emptying of hydraulic trailers, &c. The hydraulic system operates at 2200 p.s.i. and has a maximum lift at the link arms of 2600 lb. The three point linkage will take Category I and Category II implements. Alternative lower link hitch points are provided, and are used to aid penetration in very hard ground conditions.

The drawbar has been designed to meet B.S.I. standards governing the relationship of the drawbar to the power take-off, and does away with the necessity for auxiliary drawbars and adaptor plates when using power take-off driven machines built to British Standards.

Possible future variations of power take-off speed requirements have been allowed for on the B–414. There is a single clutch or non-live version at the B.S.I. speed of 540 r.p.m., and also a dual-clutch constant-running version at the same speed. Three other dual-clutch constant-running versions are offered, the first giving a speed of 745 r.p.m., actually a non-standard speed, but in the range widely used by other manufacturers so that it may be required to match existing p.t.o. implements now in use on the farm. There are two dual-speed versions, one giving either 540 or 745 r.p.m., both constant-running, and the other giving 540 or 1000 r.p.m.—the 1000 r.p.m. being the standard which, it has been suggested, will be the standard of tomorrow. The tractor has been designed also with provision for a front power take-off, and with provision for mounting a drive into the forward underside of the transmission.

Differential lock is fitted to the tractor as standard equipment. Power steering is

Fig. 11—The Byron "Bulkveyor"

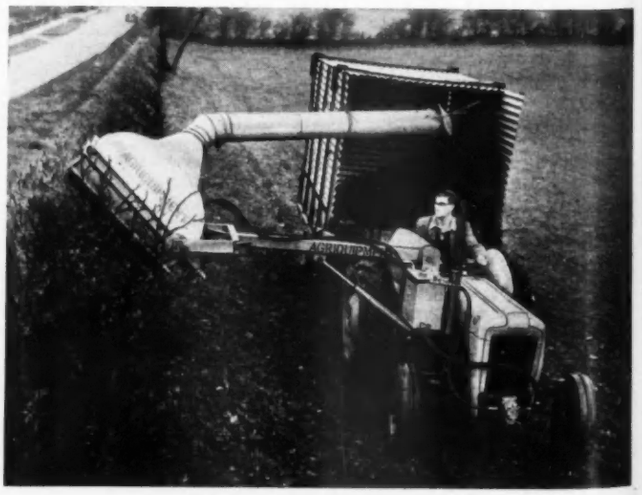


Fig. 10—The "Lupat" mid-mounted hedge cutter

Fig. 12—The Vicon " Vari-Spreader "

optional. Disc brakes are fitted, the total effective friction area being 116·8 square inches.

The " Lupat " hydraulically-driven mid-mounted hedge cutter (Fig. 10), exhibited by Agriquipment, Ltd., Yew Tree, Newall, Otley, Yorkshire, ws one of the four implements which were awarded silver medals at the Royal Show. A Dowty pump mounted on the front of the tractor delivers oil at 15 g.p.m. to a hydraulic motor developing 11 h.p. at 1800 r.p.m. at the end of the boom arm. The cutting head is made up of three banks of flails, each bank having sixteen hardened steel blades. As in forage harvesting the fan action of the flails blows the hedge clippings through the metal ducting directly into a towed trailer. As an alternative, the cutting head can be fitted with a domed top in place of the ducting, and then the clippings are finely mashed and returned to the hedge.

The ram for raising and lowering the boom arm works from the tractor hydraulic system. The cutting head of the unit can be set in eleven different positions, either by manual adjustment of a single bolt or by operation of a second hydraulic ram which can be fitted as an extra. The machine has a cutting width of thirty-eight inches.

The " Bulkveyor " unit shown in Fig. 11 is manufactured by Byron Farm Machinery, Ltd., Byron Works, Blackhorse Lane, Walthamstow, London, E.17. It can be used either for loading or unloading any type of high-sided truck. The basic unit consists of a transverse auger fitted at the rear of the vehicle which passes the load into a vertical auger fitted at the rear near-side of the body. This auger elevates the material to the 20ft boom auger. The boom auger swings through an arc of 165 deg., reaches a height of 26ft and can be lowered to ground level. Because of the " Bulkveyor " reversing boom auger, it can also be made to pick up loads.

Each auger is driven by its own hydraulic motor, which is powered by a master pump driven by the vehicle power take-off. To prevent a build-up of the material being conveyed the augers are arranged to start in sequence. For flat platform bodies an under-floor auger can be fitted, and for filling individual compartments, an overhead auger is available. Rates of loading and unloading vary according to the material being handled, but approximate ratings are—small sized grains 25 to 40 tons per hour ; meal, mash, &c., 12 to 18 tons per hour ; pellets and cattle cubes 16 to 25 tons per hour.

" Bulkveyor " equipment is made to suit bodies of standard width and body lengths of 10ft to 20ft in 2ft steps.

The " Vari-Spreader," shown in Fig. 12, was awarded the " Burke " Perpetual Challenge Trophy at the Royal Show. This is awarded to the winner of a Silver Medal whose entry, in the opinion of the judges, is of outstanding merit. Manufactured by Vicon Agricultural Machinery, Ltd., Long Street Works, Ipswich, Suffolk, the " Vari-Spreader " is driven from the tractor power take-off. It is available either as a mounted or trailed model. The unit will spread granular and powdered fertilizer, seed and grain. Up to 6 cwt. of material is held in the hopper from where it is gravity fed into an oscillating spreading basin and out through a stainless steel nozzle. The nozzle swings from side to side at high speed, rather like a pendulum, spreading the material to a width of up to 21ft. The amount of material to be spread can be regulated from 5 lb to 775 lb per acre by adjustment of the stainless steel regulating plate. In order to eliminate waste of material at row ends the supply can be cut off altogether by operation of a regulator handle. An agitator to prevent bridging in the hopper can be supplied with the unit.

Wright Rain, Ltd., Ringwood, Hampshire, displayed its new H2M " Manure Rain " tractor pump. It is a centrifugal pump with an open vaned impeller capable of taking small pieces of straw or solids. Driven from the tractor power take-off at 600 r.p.m., it will deliver 110 g.p.m. at 180ft head. A higher head model, the H3LM, is available, which with a power take-off speed of 600 r.p.m. will deliver 110 g.p.m. at 250ft head. The pump is available either trailed on a two-wheeled trolley, as illustrated in Fig. 13, or it can be mounted on the three-point linkage of the tractor.

Fig. 14—The Kemper Fräs manure spreader

The new Kemper Fräs manure spreader exhibited by Colchester Tillage, Ltd., Hythe Hill, Colchester, Essex, shown in Fig. 14, is fitted with two vertical shredders which traverse the load in a horizontal plane as it is brought to the rear of the trailer by the elevator trace moving over the trailer floor. Exceptionally fine shredding and accurate spreading of the manure without fear of blockage are claimed for the machine. Its width of spread can be varied from 6ft to 24ft. The speed of the elevator trace is adjustable and this, combined with the variable spreading width, enables precise rates of manure application to be selected. The drive is from the tractor power take-off, and the power requirement for the 2½ ton machine is 11 h.p.

The spreading mechanism can be easily removed, and by fitting a backboard which is supplied as standard equipment, the spreader becomes a moving floor or general purpose farm trailer. Silage sides and hay ladders are available as optional extras.

In these two articles we have described some of the new machinery and implements developed during the past twelve months by the engineering industry, which were to be

Fig. 13—The new Wright Rain H3M " Manure Rain " tractor operated pump

seen at the Royal Agricultural Society's annual show at Cambridge. Next year the show is to be held at Newcastle upon Tyne and there we expect to see evidence of the greater emphasis which is being placed upon machinery guards.

To-day, July 14, the Agricultural (Stationary Machinery) Regulations become fully operative. These regulations apply to all agricultural machinery designed or adapted for stationary use only on farms where workers are employed. The regulations do not apply to threshers, hullers, balers or trussers which are subject to special regulations coming into force on August 1. Components of stationary machines must be situated or guarded in such a way as to protect a worker from contact with them. Clearly marked stopping devices and means of disconnecting power must be supplied. Other requirements relate to maintenance of belts and natural or artificial lighting.

U.K. Atomic Energy Authority

No. I—REACTOR DEVELOPMENT PROGRAMME

The seventh annual report of the United Kingdom Atomic Energy Authority, published this week, covers the year ended March 31, 1961. The following extracts from the report outline the changes in the organisation of the Authority, describe operational experience with the Calder Hall and Chapelcross reactors and give some details of the Authority's reactor development programme.

AFTER a review of the structure of the U.K.A.E.A. last year several organisational changes were announced, to become effective on April 1, 1961.

Sir William Penney has been appointed deputy chairman, with primary responsibility for scientific and technical co-ordination throughout the Authority. The Authority's groups have been increased to five : namely, Research, Reactor, Engineering, Production and Weapons. The work of designing and developing nuclear reactors is being concentrated, to the greatest possible extent, in the Reactor Group, and the major development resources required for this purpose are now under its control. The group is responsible for the design and development of reactors, and for relations in this field with industry at home and with overseas countries. The Winfrith Atomic Energy Establishment which has responsibilities in the same field, is transferred from the Research Group to the Reactor Group.

The existing responsibilities of the Development and Engineering Group for the design and construction of plant, works and buildings are transferred to the new Engineering Group, which also takes over from the Production Group its responsibilities for the design and inspection of fuel elements for production purposes.

As from April 1, 1961, Sir William Cook is Member for Reactors. Sir Leonard Owen's responsibilities will extend over the Production and Engineering Groups with the title of Member for Production and Engineering.

The Calder and Chapelcross Reactors

The eight reactors gave almost trouble-free operation throughout the year. Although these reactors were designed primarily for the production of plutonium, more than 2000 million units of electricity are being sent out to the grid annually, and at the same time the reactors are providing a valuable test plant for large scale development work in aid of the civil stations.

Improved efficiency of operation has been sought in two ways : by raising the level of heat output, and by reducing the off-load time required for refuelling and scheduled maintenance. Considerable success has been achieved in both these directions. An improvement in heat output, which has had no adverse effect on fuel element life, has been obtained by raising the fuel element operating temperature, and by adjusting the loading of the reactors to obtain a more even distribution of heat in the reactor core. Electronic computers have been used to calculate optimum loading patterns of fuel elements and absorbers to achieve this heat distribution. As a result of this progressive development work, the gross heat output has been raised year by year and is now about 20 per cent above the design figure.

Further small improvements in the heat output can be expected, but the limit of development with these particular reactors is now in sight.

The Calder and Chapelcross reactors are so designed that fuel can be replaced only when the reactor is shut down. A fuel change involves the removal from each reactor of about 10,000 radioactive fuel elements, and their replacement with new elements. By careful attention to the organisation of this work, and the planning of the maintenance carried out at the same time, it has been possible to reduce the off-load period from the eleven weeks to carry out the first recharge of Calder number 1 reactor to the present period of about four weeks.

On January 31, 1961, the Calder number 4 reactor completed twelve months continuous operation, during which period it was generating electricity at full load for 95·6 per cent of the time. No shut-down due to fuel element failure was necessary during the period, the reactor ultimately being discharged for routine maintenance and change of fuel. The 4·4 per cent of the time when the reactor was not on full load was composed of : 2·5 per cent on experimental work ; 0·7 per cent on scheduled maintenance of ancillary equipment ; 0·6 per cent on unscheduled blower maintenance ; 0·4 per cent. on unscheduled maintenance of other equipment ; and 0·2 per cent on special tests on fuel elements.

The stage has now been reached at which the reactors are capable of generating more steam than can be used by the installed turbine capacity. Modifications were made during the year to some of the turbo-alternators to enable the excess steam to be utilised and the generation of electricity increased ; the remainder will be modified during the course of the next eighteen months. Moreover, it is planned during 1961 to commence the utilisation of surplus steam available at Calder in the chemical plants and for space heating on the adjacent Windscale site.

As a result of trials directed principally towards the proving of the serviceability of the elements for the first civil nuclear power stations, small but important changes have been made in the design of the fuel elements for the Bradwell and Berkeley stations.

An experiment of considerable importance was concluded successfully last autumn in Calder number 3 reactor. This reactor was operated without changing fuel from mid-1958, when it first started operation, until August, 1960. The experiment had two principal objectives. The first was to establish the probable operating characteristics which would be encountered in a large civil reactor, and the second was to obtain, by a large-scale test, further information on fuel element performance after prolonged irradiation.

The operating characteristics of the Calder reactor at an average exposure of 1000MWd(H)/ton were calculated to simulate in several important aspects the operational characteristics of the Bradwell and Berkeley reactors. Nuclear reactors such as those of Calder and Chapelcross, and the types being constructed for the electricity generating boards, are self-regulating when loaded with new uranium fuel. The self-regulating characteristic is such that the reactors will run initially at a steady power virtually in the absence of control from a control circuit or from the reactor operator. As the fuel becomes progressively more highly irradiated the characteristics of the reactor change and it is necessary to control the reactor by adjustment of the control rod positions if a steady power level is to be maintained. Theoretical predictions had been made on the control problems of large power reactors, but it was felt necessary to establish on a full scale operating reactor that the practical problems of control did not lead to reductions in efficiency of operation or to a deterioration in safety. The results obtained from this work confirmed in full the theoretical predictions and showed that the practical problems of control in no way detracted from the operating performance of the reactor, and no new problems of safety were revealed.

The information which the experiment provided on the performance of fuel elements was similarly reassuring. During this period the fuel reached an average exposure of more than 1000MWd(H)/ton. A number of channels in the central region of the core reached an exposure of about 1500MWd(H)/ton and a number of elements had been irradiated to over 2000MWd(H)/ton. The standard fuel for the Calder and Chapelcross reactors was not designed specifically to withstand the level of irradiation achieved in this experiment. The fact that it did so, and that the fuel element failures which developed (approximately 2·3 per cent) were of a type which could be recognised at an early stage and withdrawn at convenient times, gives a measure of increased confidence.

In a further long irradiation experiment in another Calder reactor a number of fuel channels had reached 2250MWd(H)/ton and some individual fuel elements had exceeded 3000MWd(H)/ton by early 1961. In the case of the civil power stations an average irradiation of 3000MWd(H)/ton has been assumed. While the Authority have no reason to doubt these assumptions sufficient time has not yet elapsed to test the civil reactor fuel elements to this irradiation.

Reactor Development Programme

The main aims of the Authority's programme of reactor development are to provide support for the first nuclear power stations now under construction for British, Italian and Japanese electricity undertakings and to pioneer more advanced types of reactor systems for the progressively cheaper generation of nuclear power. The division of effort between these two objectives is under continuous review and, while the first civil nuclear stations remain the major commitment, during the past year it has

become possible to deploy an increasing number of staff on the longer term aims of the Authority's programme of reactor development.

During the past year further comparative cost studies have been made of various reactor systems. The potential of the magnox system will be restricted by inherent limitations of the fuel materials. The advanced gas-cooled reactor using oxide fuel will operate at higher temperatures and ratings and has the potential of producing power at a lower cost. The studies have also shown that the development of both gas-cooled reactors and of some forms of water-moderated reactor could lead to still further reductions in cost. In the lower power range it is more difficult for nuclear power to compete with conventional generation, but further development and mastery of the technology of these reactor systems may lead to useful application to smaller nuclear stations. The results of these comparative studies are being used in planning the Authority's reactor programme.

A comparative economic study of various marine reactor designs was carried out during the year under review : results are reported. The main conclusion drawn from the studies is that, because of the comparatively small size of reactors required for marine propulsion, and the stringent safety precautions necessary if present reactor designs were installed in a ship, none of the reactor designs at present in an advanced state of development is economic. However, the systems so far proposed are essentially adaptations of reactors originally developed for large land-based power stations. The Authority are now considering the use of more advanced systems which are in a much earlier stage of development, to see whether these show potential for economic marine use. Other work on marine reactors over the year included the continuation of support for the Admiralty nuclear submarine programme.

Magnox Reactors

Reactor Physics.—A large digital computer programme, " STAB," has been set up to enable detailed reactor stability calculations to be carried out on the Authority's computers. The programme has been tested by first calculating the kinetic performance of the Calder reactors and then checking the results from the performance of the reactors themselves. This work yielded a fuller understanding of the effects of temperature coefficients of reactivity. These coefficients provide the magnox reactors with a measure of prompt self-stabilisation, but they can lead to slow movements in power distribution in the reactor core unless they are properly controlled. The " STAB " programme is also being used by the electricity generating boards for the solution of specific problems which may arise during the charging and operating of the civil magnox stations.

An important influence is exerted on the reactivity and kinetic behaviour of magnox reactors by the plutonium which is built up in the uranium fuel as irradiation proceeds. This effect manifests itself in increased reactivity as the moderator temperature rises. Experiments on the effects of plutonium build-up in uranium fuel are being done in sub-critical assemblies or stacks of graphite, uranium and plutonium. Experiments have been carried out at the Atomic Energy Establishment, Winfrith, in the heated sub-critical assemblies " Scorpio I " and " Scorpio II." The measured reactivity and temperature coefficient changes have been compared with estimates based on oscillator experiments with small samples, and with the experiment in one of the Calder reactors for investigating physics problems associated with long burn-up and plutonium build-up referred to above. The results of this work have confirmed that the control systems designed for the civil magnox stations will ensure adequate operational stability.

Graphite Moderator.—Data on the rate of accumulation of Wigner energy in graphite under irradiation are still coming forward from specimens in Calder and in materials testing reactors including " Dido," " Pluto " and D.M.T.R., although sufficient evidence is already available to predict the rate at which stored energy will accumulate in the graphite core of civil magnox reactors together with its effect on safety. It will be recalled that in 1958 the Authority recommended, as a precaution in view of the scanty data then available, that the fuel element channels of the civil reactors should be sleeved, but as more information on the storage of Wigner energy came to hand, the recommendation was withdrawn (Sixth Annual Report). The latest results at higher irradiations have confirmed the correctness of this decision.

Irradiation tests on the dimensional changes induced in graphite are being carried out in " Dido," " Pluto," D.M.T.R. and the Danish Atomic Energy Commission's test reactor DR.3, a British designed reactor similar to " Pluto." Information is being sought which should enable the graphite structure of reactor cores to be designed to closer limits.

Fuel Elements.—Reference is made to fuel element failures. These failures were caused either by faulty welds which had escaped detection, or by porosity in the magnox can which developed as the uranium bar grew under irradiation, thus stretching the can. The first type of failure is now very rare, and the latter type develops only slowly and only in the cooler parts of the reactor where the ductility of the magnox is lowest, but where the growth of the uranium is at a maximum.

The effects on fuel element life of the dimensional changes of the uranium bar and the lack of ductility in the coarse-grained Calder magnox were foreseen. Accordingly, a fine-grain magnox with increased ductility was specified for the civil reactor fuel element cans. The fine-grain cans will be better able to withstand the dimensional changes of the fuel, but investigation of magnesium alloys with an even higher ductility is being continued.

Under civil reactor condition each atom of uranium will, on average, be knocked out of its position every fortnight, although most of them will return to similar positions in the crystal lattice very quickly. In view of this and of the anisotropic nature of uranium, it is not surprising that irradiation produces dimensional changes. A single crystal of uranium under irradiation will grow in the direction of one axis and will contract in another ; the crystal will approximately double its length after a burn-up of 2000MWd(H)/ton at 200 deg. Cent. To avoid overall growth of the bar the crystals must be randomly orientated so that the net growth is zero. It is also necessary to have a fine-grain structure since large grains near the surface of the uranium bars can grow with little restraint and result in wrinkles. The grain size is refined by heat treatment from a high temperature, but unfortunately this process introduces a small degree of preferred orientation (i.e. departure from randomness), and the uranium bars change dimensions slightly under irradiation. There are alternative methods of producing a fine-grain structure other than by heat-treatment, such as alloying with small quantities of molybdenum and chromium. Irradiation experiments on various alloys of this type are now being carried out.

Because of the deleterious effects under irradiation of preferred orientation and of a large grain size, it is essential that checks are made on these properties during manufacture of the bar. The degree of random orientation of the crystals cannot be determined directly, but it can be deduced from a combination of measurements of the thermal expansion coefficient and the coefficient of electrical resistivity. The grain size and uniformity can be measured during the production process by a technique depending on the attenuation of ultrasonic pulses within the uranium bar.

A further problem affecting the use of metallic uranium as a fuel is the swelling which occurs during prolonged irradiation at temperatures above 500 deg. Cent to 600 deg. Cent. This is due mainly to the gaseous fission products xenon and krypton which diffuse through the metal and collect in the metal structure to form gas bubbles. Extrapolation of Calder irradiation data has shown that the magnox can should accommodate dimensional changes caused by this mechanism.

In order to carry out detailed examination of large numbers of irradiated civil fuel elements, heavily shielded areas have been set up in which metallographic examination can be carried out remotely. The civil fuel element examination line which will be used initially for Calder fuel elements is being commissioned. Another line, for the examination of A.G.R. type fuel elements, will be completed by the end of 1961.

Development work on improved equipment for the examination of irradiated fuel elements continues. For example, for the successful examination of a suspected failed fuel element it is essential that the point at which the leak occurred can be identified. Equipment has been developed for two stages of inspection ; the suspected fuel element is pressurised with nitrous oxide and by using a detector sensitive to this gas, it is established whether or not the fuel element is faulty. If it is faulty, the second stage of inspection locates the leak accurately. The sensitivity of the equipment is such that a hole 1/5000in in diameter can be located to within an area of 1/6 square inch. The small area of can is then cut away and the segment subjected to microscopic examination.

The out-of-pile testing of pre-production models of civil fuel elements under reactor conditions of gas flow and temperature has continued. Certain weaknesses of design which allowed the fuel element to move in the gas stream have been eliminated. Measurements of the gas forces which cause some deformation of the fins and splitter plates have been made. This type of out-of-pile testing is essential for the evaluation of both single fuel elements and full-length channels and several reactor channel test rigs exist in the consortia and Authority laboratories. Other tests which have been carried out include the simulation of temperature and pressure cycles which would occur during charging operations and the smaller but more frequent temperature cycling which occurs during normal reactor operation. These experiments have been carried out in pressurised furnaces and in test rigs built to simulate conditions in a reactor channel. The results indicate that, with severe thermal cycling, magnox cans will crack. There is very little thermal cycling in the Calder reactors and this effect is not a problem in those reactors. Work is in hand to establish the likely degree of thermal cycling in the civil magnox stations and its effect on the life of the fuel.

Pressure Vessel Steels.—It is important

that reactor pressure vessel steels should possess a good notch ductility and that the ductile-brittle transition temperature of plate of pressure vessel thickness should be accurately determined. To investigate this relationship a 4000-ton crack testing machine is being installed at the Authority's Culcheth Metallurgical Laboratories. This machine, which is the largest of its kind in the world, will enable a variety of brittle fracture tests including the Robertson and Wells tests to be carried out on full-scale pressure vessel plate. In this machine, steel plate of up to 4in thickness is subjected to a tensile load of 4000 tons ; a bullet is fired from a gun into a tapered hole in the plate and the conditions under which a crack is propagated are studied.

Irradiation raises the ductile-brittle transition temperature and the relationship between the increase of the ductile-brittle transition temperature and the integrated fast neutron dose has been confirmed from experiments in Calder and D.M.T.R. For example, a pressure vessel steel which has been subjected to the integrated fast neutron dose equivalent to the lifetime of a civil reactor pressure vessel shows an increase of approximately 80 deg. Cent. in the ductil-brittle transition temperature. The civil magnox reactors will be operated in such a way that the temperature of the whole of the pressure vessel will be kept above the predicted transition temperature when the vessel is pressurised.

Advanced Gas-Cooled Reactors

The A.G.R. system forms the next phase of development of the graphite-moderated, gas-cooled reactor concept beyond the magnox system. The main objective is to reduce the capital cost of the reactor installation by raising the steam temperature and thus the thermal efficiency, and by increasing the heat generation rate from a given size of reactor. It is possible to reach the necessary high temperature by using uranium oxide instead of uranium metal as fuel. To extract the heat at the required high rate, the fuel is subdivided into clusters of small rods. Uranium oxide also has the advantage of standing up to irradiation much better than uranium metal and thus has a longer life. However, the use of uranium oxide involves enriching the fuel in the isotope uranium-235. Further studies carried out during the past year confirm the development potential of the A.G.R. for the generation of electricity at competitive costs.

Construction of the Windscale reactor, a 30MW(E) experimental prototype of a large civil power station, was virtually complete at the end of the period under review (Fig. 1). The containment vessel, the turbine hall and electrical equipment, and the fuel element building were finished. The final stages of graphite laying and fabrication of the pressure circuit had been reached. Testing and commissioning of all equipment before fuel loading will start during August, and criticality is planned to take place towards the end of 1961.

Reactor Physics.—Work on the neutron physics of the A.G.R. system has been continued over the past year at Winfrith and at Windscale. The main problems are to determine the uranium-235 enrichment required to keep the reactor critical for the projected life of the fuel elements, to predict the distribution of heat production within the fuel elements so that the coolant supply is adequate, and to ensure that complete control of the reactor can be maintained throughout the fuel life. The latter problems have been studied fully for the magnox system but the use of enriched uranium oxide in the form of clusters of thin rods complicates the problems in the A.G.R.

Therefore exponential experiments have been carried out with fuel and graphite arranged in the general form required for typical A.G.R. cores.

Considerable attention has been paid to changes in reactivity following changes in temperature of reactor components, because in the A.G.R. system these effects are more important than in the case of magnox reactors. In the A.G.R. the plutonium content of fuel at discharge is expected to be substantially higher than in a magnox reactor and the geometry of the lattice is more complicated. The fuel element may be canned in beryllium and supported by a graphite sleeve ; both of these materials are moderators. The effects of moderator temperature on reactivity must, therefore, be dealt with as at least three separate components, each with a different effect on neutrons and a different heat transfer relationship to the fuel. To elucidate some of the basic neutron interaction problems with portions of moderator at different temperatures, graphite stacks with special heating arrangements and neutron detectors have been used at Winfrith.

At Windscale, the work has followed up the basic developments at Winfrith and is concerned specifically with the problems as they will arise in the Windscale A.G.R. In this investigation, the actual Windscale A.G.R. fuel elements are studied in subcritical stacks. The special neutron physics problems of the Windscale A.G.R. arise from its small size, the use of control rods and other absorbers in fuel positions. These factors affect reactivity and power distribution, and were not predictable from the earlier Winfrith experiments. The work in progress will enable commissioning of the Windscale A.G.R. to proceed more rapidly.

In the Sixth Annual Report reference was made to the " Hero " zero energy high temperature reactor. This had reached an advanced state of construction at the year's end : the civil engineering work was finished and the pressure vessel installed and pressure tested. It is expected to be made critical at the end of 1961, and, during its early operation, will supplement the information on neutron physics arising from operation of the Windscale A.G.R. As a nuclear simulation of the Windscale A.G.R., " Hero " will enable much of the neutron physics work to be done without interfering with full power operation of the Windscale A.G.R. Subsequently the " Hero " programme will determine the detailed physics of the commercial A.G.R. reactors.

Graphite Moderator.—Much attention has been paid to the reaction between graphite and irradiated carbon dioxide under the Windscale A.G.R. operating conditions. In the absence of irradiation, the graphite/carbon dioxide reaction at the operating temperatures of the A.G.R. is negligible. However, irradiation tests in Calder, " Dido," " Pluto " and D.M.T.R. indicate that, under the high irradiation intensities of the A.G.R., the reaction would reach significant proportions. The carbon dioxide molecule breaks down under irradiation. One component of this dissociation consists probably of atoms of oxygen which are chemically reactive and which attack the graphite ; this reaction manifests itself as a loss of weight by the graphite. However, small additions of carbon monoxide to the carbon dioxide coolant reduce this weight loss. There are two possible mechanisms which could explain this. The carbon monoxide may combine with the reactive oxygen atoms before these attack the graphite; also the carbon monoxide which decomposes under irradiation deposits carbon in the pores of the graphite. The second effect has been clearly demonstrated, but some doubt exists on the efficacy of the carbon monoxide in removing the reactive oxygen. The effect of these reactions on the strength of the graphite is the subject of intensive study.

Investigations into improved graphites with a low permeability to gases and good resistance to oxidation have proceeded on three major lines. Standard graphites impregnated with materials which block the pores have been manufactured. The second line of development has been concerned with varying the ingredients used in the graphite manufacturing process. Better impregnation characteristics have been obtained in one type of graphite by using a more rigorous control over the constituent materials.

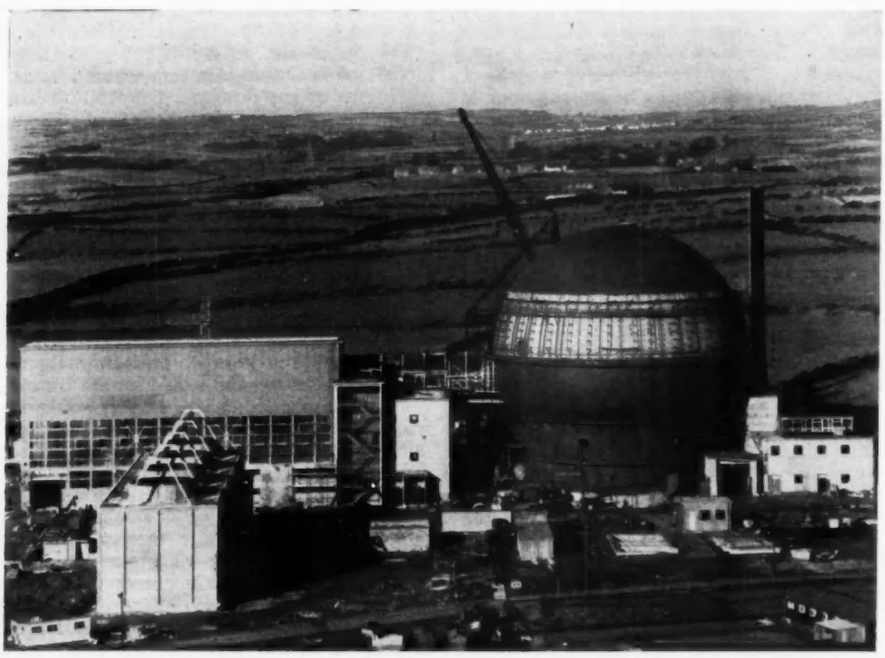


Fig. 1—The Advanced Gas-Cooled Reactor nearing completion at Windscale: four cooling towers in the foreground

Finally, new methods for the production of graphite, including cracking hydrocarbon gases on a carbonised matrix, are under development.

Fuel Elements.—Further development of the fuel pellet production process is now centred on scaling-up and making it continuous. Irradiation of uranium oxide pellets has continued in "Pluto" and D.M.T.R. These experiments have confirmed the remarkable ability of uranium oxide to retain fission product gases up to a reasonably high temperature within its crystal structure, although, as the temperature of the uranium oxide is raised beyond this, the release of fission product gases increases. The design operating temperature of A.G.R. fuel elements has been chosen at such a level that the release of fission product gases within the can is slight. Small-scale tests on A.G.R. fuel elements canned in beryllium and stainless steel have been carried out, and so far they appear to be satisfactory.

One of the main concerns about beryllium cans in the past was the formation of helium arising from the transmutation of beryllium when bombarded by neutrons. It was thought that the helium atoms dispersed in the crystal lattice would cause brittleness and after diffusion would collect at grain boundaries, form gas bubbles and cause swelling of the material. However, irradiation tests in "Pluto" taken to a burn-up of 7000MWd(H)/ton at 600 deg. Cent. show neither swelling nor increase of embrittlement; at 300 deg. Cent. there was some decrease in ductility. Further tests of the effects of irradiation on the mechanical properties of beryllium are being carried out in D.M.T.R. and in a similar reactor, "Hifar", in Australia, and by electron microscope techniques.

On the other hand, tests on the corrosion of beryllium in carbon dioxide have shown that, under the higher temperature conditions in the A.G.R., more corrosion can take place than can be tolerated in an A.G.R. Until the condition under which beryllium stands up to A.G.R. environment is clearly understood and can be specified, it has been decided to delay the introduction of a large number of beryllium-canned fuel elements into the Windscale A.G.R. Thus, instead of loading a large proportion of the initial charge of the Windscale A.G.R. in the form of beryllium-clad elements it is now proposed to charge mostly with stainless steel-clad elements. Some beryllium-clad elements will be loaded into the cooler parts of the reactor followed by a gradual loading of beryllium-clad elements into the hotter parts as material of better corrosion resistance is obtained.

A stainless steel of better corrosion resistance in carbon dioxide than the standard 18 per cent chromium/8 per cent nickel alloy has been developed with the co-operation of the British steel industry. As the wall of the fuel can for the Windscale A.G.R. is only 0·015in thick, and because it is hoped to reduce the wall thickness of subsequent designs of fuel element in the interests of neutron economy, the new steel must be completely free from inclusions. The detailed design of the fuel element cluster which must allow for expansion of the individual fuel rods and yet ensure that they cannot vibrate was a major problem to which it is thought that a satisfactory solution has now been found. Irradiation tests of uranium oxide canned in stainless steel have been carried out both in "Pluto" and in the Atomic Energy of Canada, Ltd., reactor, N.R.X. Quantity production of the stainless steel-clad fuel elements for the Windscale A.G.R. started during the year.

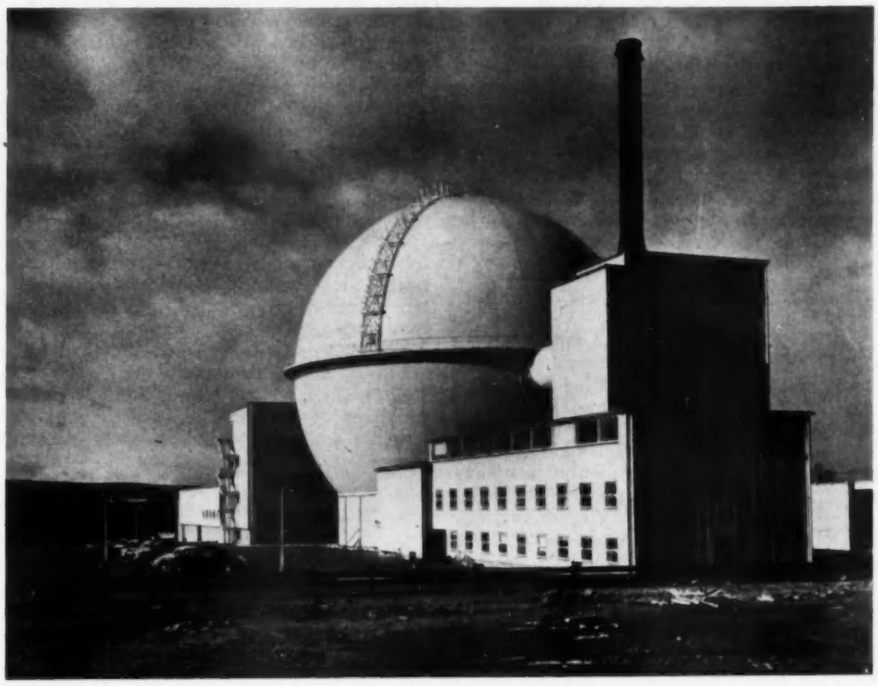


Fig. 2—Experimental Fast Breeder Reactor, Dounreay, with the secondary heat exchanger building (left) and active element storage building and administration building (right)

Apart from the information on the large-scale statistical testing of fuel elements which will accumulate with operation of the Windscale A.G.R., further tests will be accomplished in the four irradiation loops which have been provided in this reactor. The loops will enable A.G.R. fuel elements to be tested under more stringent conditions than in the reactor itself; thus it will be possible to find out the limits to which such fuel elements can be taken, and to follow the fate of a fuel element as a fault develops. Later, the loops will test more advanced types of A.G.R. fuel elements. As with the tests on civil magnox fuel elements referred to, it is necessary to subject proposed civil A.G.R. fuel element assemblies to full-scale out-of-pile tests. Accordingly, a large endurance loop to test civil A.G.R. fuel elements under appropriate conditions is now being designed.

Fast Reactor Development

During the year under review, modifications to the core structure of the Dounreay fast reactor (D.F.R.) were completed in order that more advanced fuel elements components could be tested at high temperature and high flux. The reactor was then restarted at low power, and physics experiments with the modified core arrangement were continued. Good agreement was obtained between theoretical predictions based on results from "Zeus" (the zero energy facility for D.F.R.) and the experimental results obtained on the D.F.R. The prediction of critical loading of the reactor was accurate to within one fuel element and reactivity controlled by the control rods was closely forecast. In the course of these physics experiments the reactor has operated at powers up to 1·5MW heat.

The D.F.R. (Fig. 2) is experimental and is intended to develop the technology of fast reactors generally. It is already fulfilling this purpose. Valuable operating experience on the operation of liquid metal circuits is being gained even with low power operation of the reactor. For example, it was found difficult to operate the cold trap by-pass circuits for oxide removal, and a new pumped circuit had to be installed to effect the initial clean-up before the originally installed traps could be brought into operation. Later, when running at high coolant velocities, it was found that bubbles of the nitrogen cover gas were entrained in the liquid metal coolant, causing undesirable reactivity changes within the core. The cause for this has been found and the necessary modifications to eliminate this fault were nearly complete at the end of the period under review.

The fuel element used in the present charge is of annular cross section and consists of an enriched uranium alloy in a niobium outer can and a vanadium inner can. Investigations have continued into the problems of corrosion of the niobium and vanadium in the liquid metal coolant. It has been necessary to keep the oxide and hydride content of the liquid metal down to low limits by the use of a two-stage clean-up system to prevent corrosion and embrittlement. The improvement of this fuel element to obtain better performance is under investigation.

The D.F.R. chemical reprocessing plant has been commissioned by reprocessing the first charge of fuel elements used for the low power experiments.

The next stage in fast reactor development is intended to be a plant from which commercial fast reactors will be designed. Work on this over the past year has been concerned mainly with reactor physics, with the engineering design study and with the development of the fuel element. These studies, which have been aided by parametric surveys using the electronic computers at Risley, have examined the effect of variations in design factors (e.g. coolant flow rate, coolant channel diameter, fuel rod diameter, core length/diameter ratio, breeder thickness), on the cost of power produced. This work has helped to define the important variables.

Investigations into the interactions of high-energy neutrons with fast reactor materials have been carried out using particle accelerating machines at Harwell. The zero energy breeder reactor assembly ("Zebra"), designed to study the reactor physics of large size fast assemblies, is now under construction at Winfrith. Studies of reactor kinetics and investigations into stability and control of

fast reactors are being carried out on the D.F.R.

Work on the fabrication and irradiation testing of possible fast reactor fuel materials has started. At first the irradiation testing will be done in D.M.T.R., "Dido" and "Pluto" in close association with development work on fuel fabrication and canning materials being carried out at Dounreay. Later, this irradiation work will also be carried out in D.F.R.

High Temperature Gas-Cooled Reactors

As described in the Sixth Annual Report, the H.T.G.C. reactor represents a further development of the gas-cooled, graphite-moderated reactor system and requires a far-reaching extension of the technology. By using helium as coolant and dispensing with metals in the core, gas outlet temperatures can be taken much higher than in the A.G.R. This results in a higher thermodynamic efficiency in converting heat to power and also, a more compact reactor system. The primary fuel would be highly enriched uranium-235. Dispersion of the uranium-235 in graphite and its continuous replacement by uranium-233 generated from thorium is expected to give a very long life to the fuel. Together with the high fuel ratings, this would indicate that low fuel costs should result.

The major part of the Authority effort in support of the H.T.G.C. concept has been directed towards the 20MW(H) "Dragon" reactor experiment now under construction at Winfrith under the auspices of the Organisation for European Economic Co-operation. Over the five-year life of the "Dragon" project the Authority are likely to contribute almost 60 per cent of the total financial budget. They are providing, on payment, about the same proportion of the staff engaged on the project, as well as site services. In addition, supporting research work is being carried out by the Authority under contract to the "Dragon" project. Full details of the progress on the "Dragon" reactor are contained in the annual report published by O.E.E.C., but progress on the research work carried out by the Authority under contract is given below.

The zero-energy reactor "Zenith" has been used in support of "Dragon." The experiments relating to the effectiveness of the "Dragon" control rods which were recorded in the Sixth Annual Report, were completed early in the year. Since June, 1960, experiments with a second core loading have covered a range of core and reflector temperatures up to 630 deg. Cent. and have included measurements of temperature coefficients of reactivity, of power distribution in the core and of conversion factor.

A neutron "chopper" has been installed on "Zenith" for measurements of neutron energy spectrum. The chopper is essentially a rotating disc which allows burst of neutrons from the reactor to pass down an evacuated flight tube to instruments which measure their time of flight and therefore their energy. With this apparatus, determination of the distribution of energy among the neutrons is possible, and this, in turn, enables the prediction of nuclear reaction rates for the materials in the reactor, of reactivity and of temperature coefficients of reactivity.

Because the fuel elements to be used in the "Dragon" reactor will be in a graphite container, it is important to understand the mechanism by which fission products may pass through graphite and be taken up by the helium coolant. A study is, therefore, being made of the way in which both gaseous and non-gaseous fission products diffuse out of graphite crystals and also through the pores of a polycrystalline mass of graphite. The chemical interactions of fission products with graphite are also studied. Because of the leakage of fission products from the fuel through the graphite container, the helium coolant in the "Dragon" reactor will be contaminated with volatile fission products and equipment will be required for their continuous removal. A combination of low temperature (−196 deg. Cent.) condensation and adsorption equipment has been recommended and design information has been provided to the "Dragon" project.

At the high operating pressures and temperatures of the coolant in the "Dragon" reactor, the large gas blower presents special problems of materials of construction, gas bearings and gas seals. A great deal of design and operating information on gas bearings and seals has been accumulated by the Authority, and this information has been made available, under a commercial access agreement, to the suppliers of the main gas circulators for the "Dragon" reactor.

In addition to their work in support of the "Dragon" project, the Authority are investigating the possible applications of the high temperature gas-cooled reactor systems to both marine propulsion units and to large, land-based power stations. Particular attention will be paid to the fuel cycle. Whereas the fuel cycle proposed for the "Dragon" reactor starts with uranium-235 and thorium and, in a large reactor, would be theoretically almost self-maintaining through the production of uranium-233 from the thorium, the Authority are extending the investigations to the plutonium/thorium/uranium-233 cycle.

(*To be continued*)

Soviet Exhibition at Earls Court

No. II—(*Continued from page* 11, *July* 7)

We continue our account of the Soviet Exhibition which opened at Earls Court last week and is due to continue until July 29. *With displays grouped in twenty-two principal sections, covering all major fields of economic and cultural activity, the Exhibition seeks to convey to visitors an impression of what life is like in the Soviet Union at the present time.*

AFTER passing through the Entrance Hall where various basic facts about the Soviet Union are displayed and a number of films depict life in various parts of the country, the visitor enters the Hall of Science. Here examples are to be found of the work carried out under the aegis of the Academy of Science. Research on ultrasonics is typified by an ultrasonic concentrator in which a large number of piezo-electric generators are mounted on the inside of a hemispherical bowl. At the focus, a density of energy of 20kW per square centimetre is produced over a diameter of 3mm. The working frequency is 1 Mc/s. For industrial purposes (cleaning, ultrasonic machining) magneto-strictive transducers with efficiencies of 70 to 80 per cent are becoming available in the form of wound ferrite cores. Also shown was a barium titanate piezo-electric micro-probe for the mapping of ultrasonic fields.

Much attention is being paid to the development of spark erosion as an industrial tool.

A hand-operated vibrator is demonstrated which is designed to deposit hard facings on cutting edges, &c., requiring about ten minutes for a 30mm long, and a 5mm wide edge.

Oceanographic research is represented by a model of the non-magnetic research vessel "Zaria," which recently completed a cruise of 100,000 miles, mostly in the Pacific, for the purpose of studying the earth's magnetic field.

Approximately in the centre of the exhibition is the section devoted to Outer Space, where full-size replicas of sputniks and space probes may be seen, as well as of the space-ship in which Major Y. A. Gagarin circled the earth on April 12. Documentary films concerned with preparation for manned space flight, and the launching of space probes and satellites were shown on projectors.

Adjoining the Space Section is the Hall of the Optical Industry. Many of its products in the camera field are already known in Britain. Among new models were the "Zorky-6," the "Lubitel-2" reflex camera, and the "Quartz-1" and "Sport" cine cameras.

Scientific instruments include telescopes and microscopes, among them a luminescence

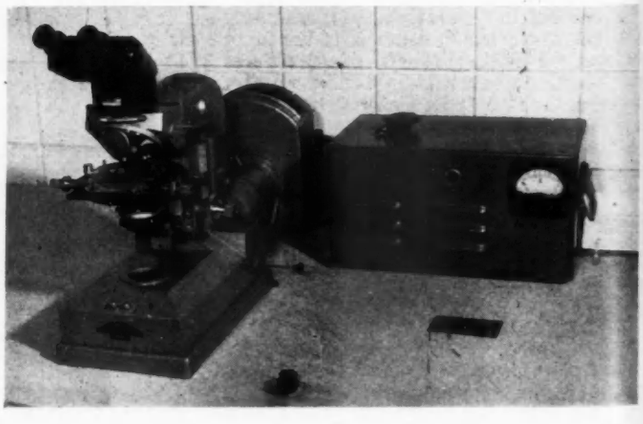


Fig. 3—Luminescence microscope for the visual and photographic study of biological specimens

microscope (Fig. 3) developed for the re-examination of specially stained living tissue in ultra-violet light, a method which *inter alia* is applied to the diagnosis of cancer. Also shown were electron microscopes with resolving powers down to 10Å with linear magnifications of up to 300,000 times.

Development of the system of power transmission is outlined in documentary films in the Power Section. Whereas in 1950 transmission lines of 11kV and over totalled nearly 33,000km the figure for 1958 had already exceeded 89,000km. By 1965, the Seven-Year Plan envisages the completion of a total of 310,000km, including an 800kV d.c. transmission Stalingrad-Donets which is to be commissioned next year.

As was mentioned earlier on, the 60,000MW increase in generating capacity which is planned to be achieved by 1965 will be to an extent of 80 per cent thermal power, exemplified at the Exhibition by models of a 2400MW thermal power station (Fig. 4), and "PK-39" once-through 950 tons per hour boiler for burning coal of a high ash content. Steam conditions at the stop valve of the "PK-39" are 255 atmospheres absolute, with a superheat of 585 deg. Cent. and reheating to 570 deg. Cent. at 39 atmospheres absolute. A 300MW turbo-set for use with this boiler is also shown. The feed temperature is 260 deg. Cent., and the condenser pressure 0·035 atmospheres. Specific fuel consumption, it is claimed, is 1830 cals per kilowatt hour. The design of a single-shaft turbine of 500MW is stated to have been completed.

Power station construction is the subject of one of the film shows which illustrates the extensive use of prefabricated reinforced concrete for the buildings.

The construction of transmission lines presents difficult transport problems on account of the nature of the terrain which frequently is extremely rugged, and the climate, which varies from arctic to desert. Films show that prefabricated concrete pylons are being widely used.

Also in this section are displayed some large pieces of equipment. One, a model "BB-500" airblast circuit breaker has a rated voltage of 500kV, a current rating of 2000A, and a breaking capacity of 20,000 MVA. The maximum short circuit current amounts to 23,100A. The breaker which functions in a total time of 0·06 seconds operates with compressed air at 20 atmospheres and can be used in temperatures down to −45 deg. Cent.

A 1 : 10 model of a single-phase outdoor transformer with a rating of 135,000kVA may also be seen here. Designed for a no-load voltage of 525kV, its total weight is 235 tons.

A 1 : 200 model of Bratsk hydro-electric station offers a glimpse of the vast scale of this project. The dam of the power station is approximately 125m high, and comprises an 800m-long concrete section ; the total length is 1452m. The station's installed capacity of 4500MW will come from a total of twenty sets. They are being built for a head of 92m to 106m, and for heads over 100m will develop their full rated power. Fitted with turbines having runners 5·5m in diameter, the 125 r.p.m. sets will produce an average annual output of 22·6 billion kWh.

Fig. 5—Open-air turbine sets at Kremenchug hydro-electric power station

Another important station of the Volga Cascade is Saratov where twenty-four units of 57·2MW each are installed. This is an example of the use of prefabricated elements in the construction of a hydro-electric station. Another way of reducing cost and speeding up construction is the use of outdoor turbo-generator units as at Kremenchug (Ukraine), illustrated in Fig. 5.

From conventional power, the visitor comes to nuclear power production and research. Because of the present abundance of fossil fuels, nuclear power on a large scale is something for the future, but that it is a subject which is being actively pursued, is shown among other things by the various nuclear power stations which have either been built or are being planned. Besides a model of the first nuclear power station which had an electrical output of 5MW, there is to be seen the "I. V. Kurchatov" nuclear power station at Beloyarsk, with two reactors each of 100MW, having as fuel 1·3 per cent enriched uranium which is graphite-moderated, with superheating of the steam produced which has a temperature and pressure of 510 deg. Cent. and 100 atm.

Other designs which are being actively pursued and here are shown as models are a 50MW graphite-sodium reactor cooled by liquid sodium ; the "BN-50" fast neutron reactor which is designed to produce an output of 50MW and is filled with 10 per cent enriched uranium and cooled by liquid sodium ; and a 50MW boiling water reactor with 1·5 per cent enriched uranium.

Research into controlled fusion is said to have begun in 1950, and in 1952, a temperature of 1,000,000 deg. Cent. and fusion neutrons are stated to have been obtained by discharging a bank of condensers through a cylindrical chamber. An apparatus similar to "Zeta," called the "Alpha Doughnut," has been operated without giving, evidently, any better results than the British machine. Shown as a model and the subject of a short film, is the "Ogra," a large adiabatic magnetic trap with an internal diameter of 1·2m. The object of this machine is to compress high temperature plasma and to build up its temperature until some of the hydrogen nuclei fuse into helium.

(To be continued)

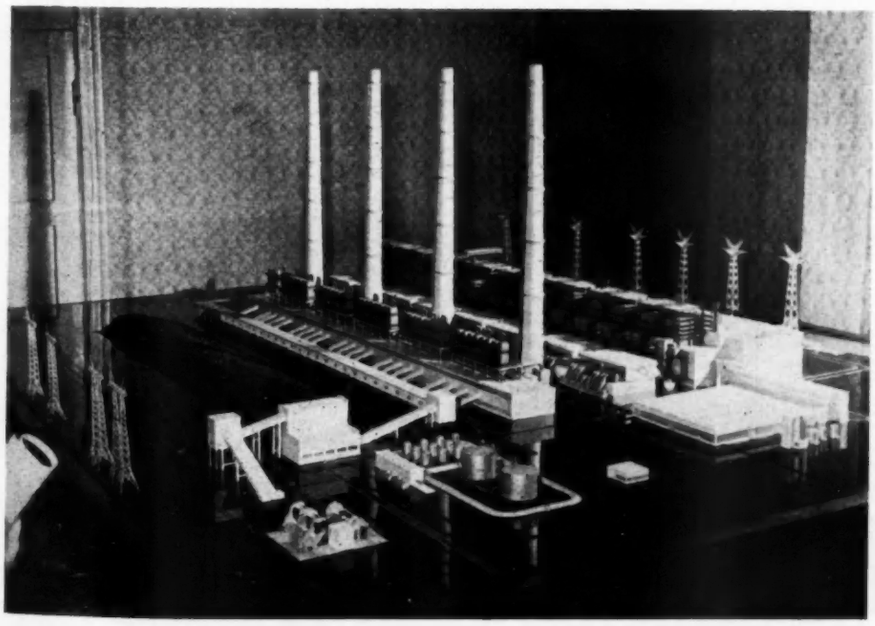


Fig. 4—Model of 2400MW thermal power station. On the right is the turbine hall, followed towards the left by the open-air, uniflow boilers, chimneys with dust extraction plant and coal storage area

LITERATURE

Book Reviews

Statistical Processes and Reliability Engineering. By DIMITRIS N. CHORAFAS. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 96s.

ONE of the main trends of modern engineering is the steady increase in sheer size and complexity of much of the equipment, especially electronic equipment (e.g. computers, automatic exchanges), and also in the inaccessibility of some apparatus (such as satellites, submarine telephone repeaters). This movement has brought into prominence the importance of system reliability, a factor which was already of serious concern, in certain fields, during the last war.

Probabilities of error, control of component manufacture quality, reliability of complete systems, can no longer be left to casual inspection, to arbitrarily tightened limits and tests, but must be measured and controlled in strictly systematic ways using all the devices of mathematical statistics. This book is a survey of the relevant statistical techniques and of their application to reliability engineering. It covers an extremely wide field of interest; too wide, in this writer's opinion, adequately to cover most of the topics. It would have been better to have omitted certain chapters, especially those concerned with cybernetics and information theory, and to have expanded on some of the statistical techniques and illustrating by more examples.

The book is divided into six parts. Part A begins on the ground floor of statistics and probability theory, using many pictorial illustrations and graphs and introducing the standard statistical distributions—Normal, Binomial, Poisson and others. The elements of statistical inference are outlined; testing of hypotheses when distributions are unknown (non-parametric statistics); types of correlation.

Part B deals with estimation of statistical parameters, with confidence tests and intervals, with curve fittings and regression analysis. Further treatment of inference follows; further types of correlation, analysis of variance and its relation to experimental design (e.g. comparison of the effects of different processings on variation of quality of a product). The use of Latin squares is explained. Selection of those variables which control variations in a process from the mere chance variables is described, followed by some treatment of factor analysis, concerned with the determination of the controlling variables from the matrix of correlation coefficients—most important aspects of our present subject.

Part C gives an introduction to probability theory; algebra of sets, notation of symbolic logic, description of combinations (e.g. of events) and statistical independence. Markoff chains and other sequential processes lead to the random walk and the Monte Carlo method (not treated fully enough). Applications are outlined to estimation of the life of assemblies of components of known expected life and deviations.

The next section deals with cybernetics, which is interpreted as the general theory of all conceivable machines and analogous organic systems. It further gives a treatment of information theory; but this section seems to be the least satisfactory of the whole book. The treatment is unnecessarily complex, far from lucid, and "pseudo-philosophical." For example it contains such cryptic statements as: "In communication theory the word 'semantics' is related to channel capacity."

The book returns to the subject in Section E on quality control, starting with sampling procedures, quality control charts and their use, following with the use of Operating Characteristics curves (possibility of acceptance of a product, to given standards, when the components are defective). Multiple and sequential sampling plans for quality control are treated, with a discussion of the reliability of complex systems and of the need for much more intensive study.

The final Section F is very much concerned with reliability engineering in the factory. The treatment is mainly non-mathematical, giving accounts and descriptions of real-life experience of quality control and reliability engineering.

It remains to add that the index is scarcely full enough to cover adequately all the items which might well be sought by the reader in the book covering so wide a range of subjects as this does.

Staff in Organisation. By ERNEST DALE and LYNDALL F. URWICK. McGraw-Hill Publishing Company, Ltd., McGraw Hill House, 95, Farringdon Street, London, E.C.4. Price 46s. 6d.

BUSINESS management, for long one of the most neglected subjects of study, is fast becoming one of the most intensively cultivated; but, despite the stream of books that now issues from the presses, this is one that deserves special consideration. The growth in the size of the individual firm has confronted business men with problems of organisation and administration for the solution of which they have no training or preparation and for which they are often temperamentally unsuited. They are inclined, therefore, to try and deal with each problem as it arises by indulging in a proliferation of appointments, without giving due care to establish the exact functions of each post and its relation to the duties of others.

What, for example, is the work that should be done, and what the qualities required by an "assistant-to" a particular official? What is the difference between an "assistant-to" and a "deputy"? In the absence of a chief, who gives the decisions? Does the rest of the personnel know that this is the man to whom matters should be submitted? What are the similarities and what are the differences between the general staff of the army and the general staff of a big industrial enterprise? What is meant by the "chain of command" or by "co-ordination" or by "communication"? How and where does the specialist fit into the managerial hierarchy?

By a series of short but very telling case histories—many of them of the nature of "awful warnings"—the authors show the dangers that arise if sufficiently clear and careful thought is not given to these questions and, in particular, if there is lack of clarity in definition of functions, responsibilities and relationships; and suggest the organisational techniques by which such dangers might be overcome.

The book ends with a particularly valuable chapter on the practical use of general staff positions in business and gives a list of essential "do's" which, despite the wide variety of industrial structure, apply in almost all cases.

Technical Writing Techniques for Engineers. By JOSEPH RACKER. Prentice-Hall International Inc., 28, Welbeck Street, London, W.1. Price 45s.

THIS book—which appears from the jacket to apply to "people in all areas of the engineering field"—relates almost entirely to writing problems in the American electronics industry. Of its 234 pages, 106 are devoted to a Glossary of Technical Terms (containing a misprint on page 131). Nine of the remaining pages deal generally with the subject matter, and some useful points are made; on the other hand, "Rule 7" in List 5.1 on page 121—and the expansion of this advice on the following page—would be unlikely to find favour with responsible technical authors in Britain, and from the standpoint of training could be decidedly harmful in that it tends to encourage the use of an unsound method. The example quoted on page 127, indicating lack of basic technical knowledge on the part of a technical author, is, however, something which we could well take to heart here, judging by last year's Examiners' Report on this subject.

The remainder of the book—the first 119 pages—deal almost exclusively with American methods of tackling various problems in writing electronics instructional and other material, but the text is so heavily loaded with technical detail that the original object of the book—"writing"—appears to have become submerged in the process.

Viewed as an example of technical publications techniques, by British standards there are many points which can be criticised: possessive case and misuse of indefinite article (page 128); lack of hyphenation (page 123); verbosity "It is seen that..." (page 27); use of words such as "return" and "replace" when the operation to be defined is "refit" (pages 26 and 45); unsuitable sizing of original illustrations or annotations having regard to final sizes on reproduction (pages 86, 88, 99 and 107); an unfortunate discrepancy in the line drawings of wave-forms (page 116)—as a result, the point which the author was endeavouring to make on page 115 about the superiority of line reproduction has been entirely lost.

Books Received

Penguin Science Survey 1961. Part 1. Edited by Arthur Garratt. Penguin Books, Harmondsworth, Middlesex. Price 6s.

Penguin Science Survey 1961. Part 2. Edited by S. A. Barnett and Anne McLaren. Penguin Books, Harmondsworth, Middlesex. Price 6s.

Topology. By John G. Hocking and Gail S. Young. Addison-Wesley Publishing Company, Inc., 10-15, Chitty Street, London, W.1. Price 74s.

Axial-und Radial-Kompressoren. By B. Eckert and E. Schnell. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, West Berlin. Price DM 89.

Electronic, Radio and Microwave Physics. By D. E. Clark and H. J. Mead. Heywood and Co., Ltd., Carlton House, Gt. Queen Street, London, W.C.2. Price 130s.

Technische und Wissenschaftliche Berichte der August Thyssen-Hutte, Vol. 1. Werkzeitung August Thyssen-Hutte A.G., Duisburg-Hamborn, Franz-Lenze-Strasse 3, W. Germany. Free.

Boiler Plant for Trawsfynydd Nuclear Power Station

Good progress has been made in the construction of Trawsfynydd nuclear power station since work was started on the site two years ago. The station is being built for the Central Electricity Generating Board by Atomic Power Constructions, Ltd. On a recent visit to the site and a subsequent visit to the Derby works of International Combustion, Ltd. (a member of the A.P.C. consortium), we saw work in progress on the boilers and other items of plant making up this company's contribution to the Trawsfynydd scheme.

TRAWSFYNYDD nuclear power station is designed from a net station output of 500MW(E) from two gas cooled graphite moderated reactors fuelled with natural uranium. It is the first C.E.G.B. nuclear power station to be sited away from the sea and cooling water will be obtained from an artificial lake adjoining the site. The main particulars of the station are tabulated below.

Main Particulars of Trawsfynydd Nuclear Power Station

Performance :	
Guaranteed output	500MW
Reactor heat output	870MW
Reactor inlet temperature	200 deg. Cent.
Reactor outlet temperature	399 deg. Cent.
Design max. fuel element temperature	440 deg. Cent.
Gas pressure at reactor inlet	240 lb per square inch gauge
Gas flow rate	9000 lb/s
Fuel :	
Material	Natural uranium rods
Diameter of rod	1·125in
Number of rods per channel	Nine
Number of rods per reactor	33,480
Weight of uranium per reactor	280 tons
Canning material	Magnox
Fins	Longitudinal spiral
Sleeves	Graphite
Graphite Core :	
Height of active core	24ft
Diameter of active core	44·5ft
Number of fuel element channels	3720
Lattice pitch	7¼in
Number of control rod channels	241
Total weight of graphite per reactor	1900 tons
Pressure Vessel :	
Shape	Spherical
Internal diameter	61ft
Plate thickness	3¼in
Plate material	Silicon-killed carbon manganese steel
Operating pressure	240 lb per square inch gauge
Control Rods :	
Control rod material	Boron steel
Number of rods per reactor	185
Length of control rod	26ft
Diameter of control rod	2½in
Weight of control rod	215 lb
Main Circulators :	
Type of circulator	Single stage axial
Number per reactor	Six
Type of drive	Constant speed
Type of motor	Squirrel cage induction motor
Blower power	6200 h.p.
Running speed	2950 r.p.m.
Main Ducts :	
Number per reactor	Six
Diameter	5½ft
Plate thickness	15/16in
Boilers :	
Number per reactor	Six
Type	Shell and tube
Diameter	18ft
Height of shell	109ft 6in
Shell material	Boiler plate
Shell thickness	2¼in
Boiler tubing	Tube products extended surface
Turbo-Generators :	
Number of sets per station	Four
Continuous maximum rating	145MW
Speed	3000 r.p.m.
Stop valve conditions :	
H.P. pressure	927 lb per square inch gauge
H.P. temperature	715 deg. Fah.
L.P. pressure	290 lb per square inch gauge
L.P. temperature	685 deg. Fah.
Final feed temperature	220 deg. Fah.

This article is concerned only with the boiler plant and some of the other equipment supplied by International Combustion, Ltd. ; it outlines the fabrication methods adopted in the works and on site.

Each of the twelve boilers for Trawsfynydd is 18ft in diameter, 109ft 6in in height and the empty shell weighs 350 tons. Because of the size of the shell much of the fabrication work has had to be done in a shop specially built for this purpose on site. However, for technical and economic reasons the policy has been to do the maximum amount of fabrication at the Derby works, and to transport the work in the the largest possible components to Trawsfynydd, thus keeping the site welding work to a minimum.

Existing routes would not have proved adequate for transporting boiler components to site. After investigation of various alternatives it was decided to carry out extensive improvements to the harbour at Portmadoc and to the 12 miles of road between this port and Trawsfynydd. These developments enabled International Combustion to transport completed boiler strakes 18ft diameter and 9ft 6in maximum height. They are carried by road from Derby to Liverpool where they are loaded on to small coastal ships and taken by sea to Portmadoc. The last stage of the journey is by road to site.

Height restrictions on the road from Derby to Liverpool necessitate carrying the strakes with their cylindrical axes vertical, while restrictions on the road from Portmadoc to Trawsfynydd require the strakes to travel with their axes horizontal. To meet these requirements special equipment has been designed to turn the strakes over during transhipment. The development of Portmadoc harbour has included the provision of a 150-ton crane on the quay.

Because of the high centre of gravity of the strakes with their axes horizontal, a special ballasted trailer is used to avoid risk of the loads overturning on the road between Portmadoc and Trawsfynydd, which at one point has a 1 in 12 cross fall. Two heavy-duty towing vehicles are used to haul the total weight of approximately 50 tons of load and ballast on a maximum gradient of 1 in 7.

At Portmadoc harbour, ships of the size required can only enter the harbour for three to four hours on either side of high water, during a period of five to seven days before and after monthly high spring tides. Careful programming of all operations is therefore necessary to ensure a steady flow of equipment to the site fabrication shops in the correct sequence.

Boiler Work on Site

The fabrication workshop on the site is at the nothern end of the " Goliath " crane tracks. It is a " T "-shaped building (Fig. 1) containing areas for boiler and ducting fabrication and element cleaning as well as for storage maintenance, laboratory work and administration services.

After being unloaded the boiler strakes are " paired " on manipulator beds (which can be seen in the foreground of Fig. 2) in preparation for circumferential welding. For restoring circularity and edge matching during " pairing " the strakes are fitted temporarily with spiders having eight independently adjustable arms (Fig. 2). The " paired " strakes are then lifted by a 60-ton crane and placed on one of the assembly lines which can be seen in the background of the picture. To suit the site contours these two areas of the shop have different floor levels, as indicated.

Boom welding equipment for making the circumferential seam welds is shown in Fig. 2. This machine can travel along rail tracks in the shop floor and the column carrying the boom can be rotated on the turntable above the baseplate. The shell manipulator is rotated at a speed which can be adjusted to suit welding requirements. All the speed and welding controls are exercised by the

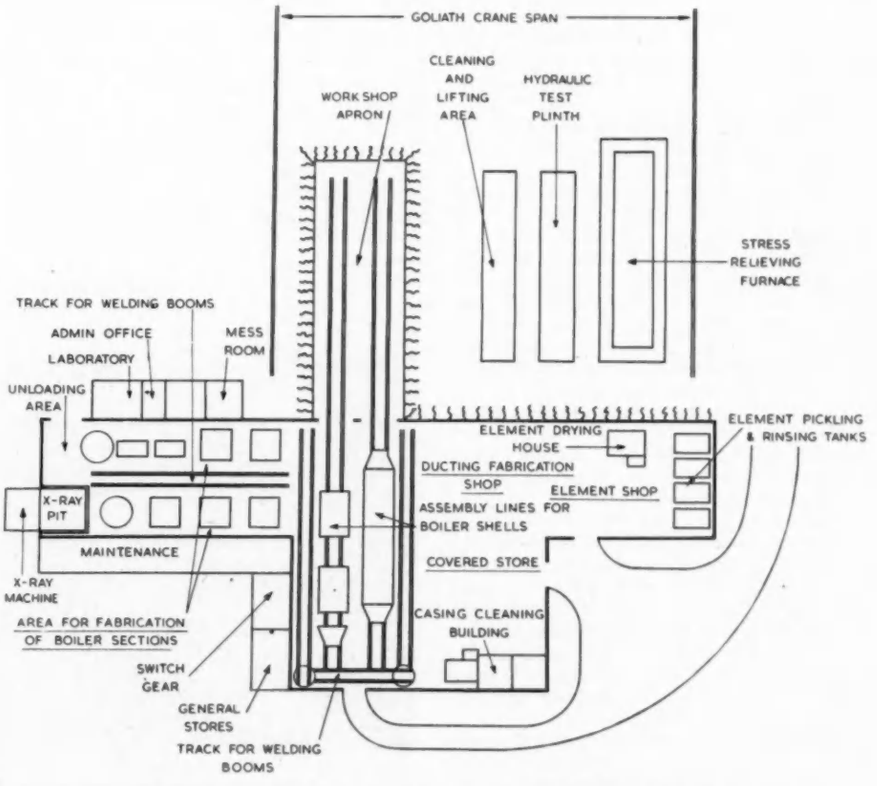
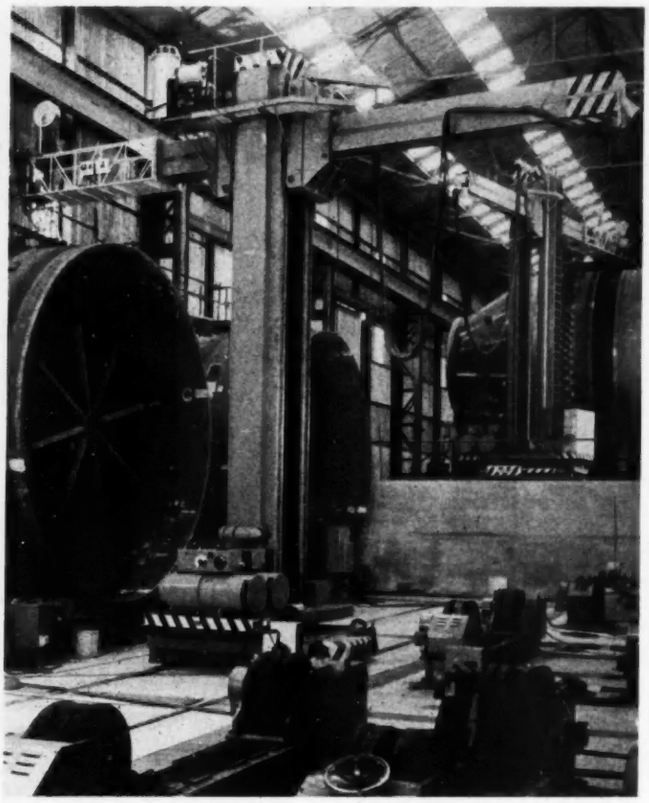


Fig. 1—Layout of International Combustion site workshop area at Trawsfynydd



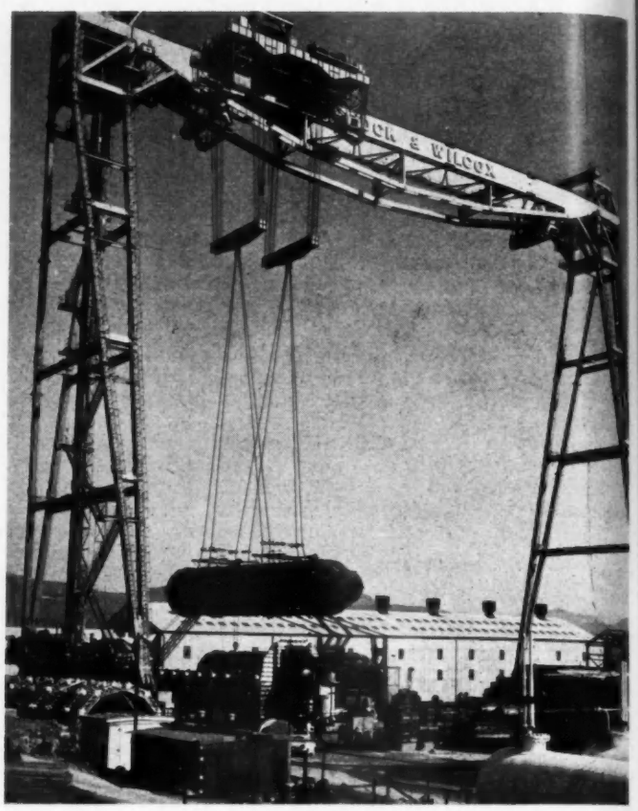


Fig. 2 (Left)—Manipulator beds and strakes in the boilermaker's fabrication shop at Trawsfynydd Fig. 3 (Right)—400-ton " Goliath " crane lifting a completed boiler shell into the stress relieving furnace

welder working in the cantilevered part of the welding head.

The completed boiler shells are removed on the rotators, and, when clear of the shop, are lifted by the " Goliath " crane (Fig. 3) and set down on the stress-relieving furnace pedestals. Thermocouples are fasted to the vessel at about ninety-six points internally and externally, which are in turn connected to instrument panels mounted in the adjacent control cabin. Metal temperatures are closely watched and controlled here during the period of temperature raising, soaking or relaxing.

The roof of the furnace (Fig. 4), comprising fifteen sections, each of which weighs 5 tons, is replaced on the furnace body and sealed to prevent loss of heat during the heating cycle. Two oil fired combustion chambers, one at each end of the furnace, provide hot gas to the furnace. A gas recirculating fan discharges hot gas through the ducting into the vessel. The circulation of the hot gas continues through manhole doors, which are left opened on the outside of the vessel, and into the furnace where there are sufficient vents for pressure release. The shell is heated from ambient temperature to 600 deg. Cent. at which it is maintained for five hours, and then left to cool to ambient. Depending on the prevailing weather conditions, the whole process takes about seven days.

Test plates, inserted both inside and outside the vessel during stress relieving, are afterwards tested in the laboratory to ensure that the plate has been returned to its proper ductility and tensile strength after relaxation of the tri-axial stresses, caused during welding.

As the furnace will only be used twelve times on this site it was designed to be economically removable in sections for re-erection and use on other sites.

After it has been stress relieved, the boiler shell is lifted from the furnace by the " Goliath " crane and lowered on to the adjacent hydraulic test plinths. Metal caps, used to cover the thermal sleeves during stress relieving, are removed and replaced by screwed steel covers to withstand the hydraulic test pressure of 460 lb per square inch. Domes are welded on to the inlet and outlet sleeves and manhole doors are securely fastened. Water from the Trawsfynydd lake is then poured into the vessel in several stages totalling 800 tons. At each stage, water is circulated through electric heaters of 520kW capacity to maintain a reasonable shell temperature throughout the filling operation.

When the vessel has been filled and the air extracted, pressure is raised to 460 lb per square inch by means of a three-throw ram pump. At the end of the test, pressure is dropped and the vessel emptied. The seals are cut away from the sleeves of the vessel, which is then prepared for internal shot-blasting.

After the hydraulic test, the boiler shell is lifted by the " Goliath " crane and placed on the cleaning and lifting plinths. The end domes and internal bracings are removed, and the inside of the vessel is shot-blasted from end to end. Seals are provided to prevent contamination of the clean areas during this operation. Permanent supporting steelwork for the banks of tube elements is installed, and the interior is painted with " Strathclyde PA21 " to preserve cleanliness.

For lifting the boiler shell to its final position, a tail-car structure is provided which transposes the vessel from a horizontal to a vertical position on the initial lift (using a lifting girdle). This tail-car, which is designed for a maximum load of 70 tons, can traverse a track as the vessel changes its

Fig. 4—Roofing the stress relieving furnace with a boiler shell in position

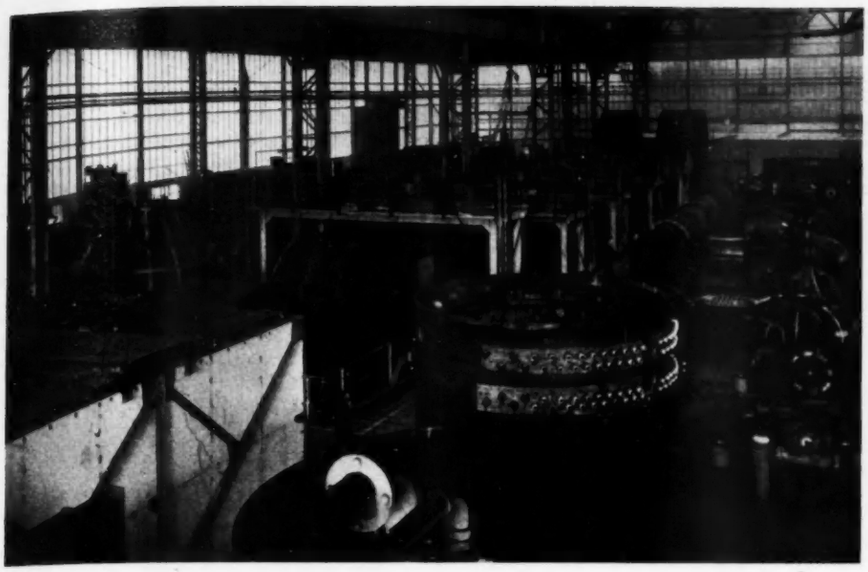


Fig. 5—Main fabricating shop at Derby showing boiler shell strakes in various stages of manufacture

inclination. Before the component reaches its vertical position, all load is taken on the lifting girdle. The vessel is finally transferred by the "Goliath" crane to its permanent position next to the reactor.

In the meantime the tube elements delivered from the Derby works will have been cleaned externally in a hydrochloric acid pickling tank, a citric acid washing tank and water rinsing tanks. After this cleaning the elements are dried by hot filtered air and placed in canisters which have been cleaned by a similar process.

During erection and tubing of the installed shell, a clean conditions hut is positioned on the top of the boiler to exclude all foreign particles from the shell interior. The supply of air to the shell interior is at a pressure slightly higher than atmospheric, and filters and dehumidification plant keep out moisture and solid particles. The clean conditions hut is provided with an air-lock to maintain pressure inside the shell ; changing rooms are also included and all personnel in this area wear clothing to meet the high standards of cleanliness required.

All tube elements delivered from the site workshop are lifted into the clean conditions building and removed from their canisters within this building. The clean tube elements are lowered into the boiler shell and placed in position from the permanent steelwork previously installed when the shell was horizontal.

When all the tube elements have been placed in position, the ends of the boilers are sealed and the clean conditions hut removed. To exclude foreign particles before installation of the gas circuit, nitrogen bottles are used to inject gas into the boiler, thus ensuring that the pressure is slightly above atmospheric pressure. On completion of the gas circuit and final boiler welds, the full gas circuit, including the reactor and boiler vessels, is subjected to a pneumatic pressure test.

In the boiler shell the tube elements are arranged transversely to the coolant flow, and, where the elements pass through the pressure vessel wall, suitable sleeves are provided to avoid the incidence of undesirable stresses. All penetrations of the tube elements through the pressure vessel are radial and are from the same side of the banks, an arrangement which reduces the amount of external pipework required and also simplifies the construction of the internal baffles. The boiler is arranged to suit a dual pressure steam cycle and has one l.p. and one h.p. steam drum. The evaporator banks consist of double flow tube elements and thus bifurcations are used to reduce the number of holes in the pressure vessel wall and also the number of thermal sleeves. Assisted circulation through both h.p. and l.p. evaporator banks is employed, the circulation pumps being of the glandless electro-mersible type.

At the top of the boiler are the h.p. and l.p. tube banks, which are followed, in order, by the h.p. evaporator, the h.p. economiser, the l.p. evaporator, and the mixed economiser.

Heavy Engineering Shop at Derby

The boiler strakes for Trawsfynydd are fabricated in a new heavy engineering shop of 68,250 square feet which was completed in the Derby works early in 1959. The shop is divided into three bays, the centre of 75ft, and each wing bay of 65ft in width. The overall length is 350ft, and the height from the floor to crane rails is 40ft. To provide additional headroom for the construction of very large diameter vessels, the centre bay contains a welding pit 150ft long by 25ft wide by 12ft deep. The floor of the pit carries manipulating equipment for rotating vessel sections during seam welding, and also provides an adequately screened space for X-ray examination in addition to the main X and gamma ray booths at the north end of the shop.

Layout of machinery around the shop perimeter is suited to progressive stages of manufacture, each bay being served by two cranes, the heaviest of which is of 50 tons lifting capacity. Thermal insulation of the building is provided by double panelling, either in the window glazing, or the general panel and roof covering.

Raw material taken from the stock yard is transferred into the main shop through the flame planer building, where the plates can be cut to size or shape, and initial weld preparations formed on the plate edges. Further edge preparation for welding is done on either a large planer accommodating plates up to 35ft in length, or on a standard planer which has a table 25ft long. Circumferential weld preparation is done on a large centre lathe, or on a vertical boring machine.

Two vertical presses, each of 3000 tons capacity, together give a range of plate bending in various widths from 3in thick (cold) at a minimum diameter of 3ft, up to 4in thick (cold) at 25ft diameter. A four-column downstroking press of 2000 tons capacity provides for the hot pressing of dished ends, and segments for all diameters of vessels and drums. Lighter sections of plate are manipulated in the power rolls up to 1½in in thickness.

The main welding machine is an automatic welder with a rising boom to accommodate vessels up to 12½ft diameter, and 50ft long. These vessels are manipulated under the welding head by means of a roller bed installation. There are several other self-propelled automatic welding machines. They are used together with such standard direct current and alternating current sets as are required for the work in progress.

Three furnaces grouped at the south end of the shop provide for the heating of plates for dishing, and the heat treatment either of long medium diameter vessels, or of large diameter sections of vessels. These are all town mains pressurised gas-fired furnaces, with full automatic temperature control, and temperature recorded throughout the whole process. Two electrically heated furnaces are also situated at the south end of the shop for stress relieving nuclear strake sections.

The largest machine installed is a vertical borer which can be adjusted for work on vessels up to 25ft diameter, and provides for cylindrical edge preparation, general boring and facing. There is also a floor boring machine with a 3in diameter spindle. Tube hole drilling, and profiling tube stubs for welding, are done on a duplex horizontal boring machine. Further drilling machines for angular boring, facing and plate drilling are installed.

For the cylindrical part of the Trawsfynydd boiler shells boiler plates of 2in to 2½in thick are cold bent to semi-circular shape, two of which are then welded longitudinally to form a cylindrical strake. Cylindrical Strakes in various stages of manufacture can be seen in Fig. 5. The two seen in the background are ready for radiography of the longitudinal seams. At this stage the location of thermal sleeves will have been marked and pilot holes drilled. Later holes will be flame cut for all thermal sleeve openings and the thermal sleeves will be welded in. Then after passing crack-detection tests from the thermal shield to the shell fillet weld the whole strake will be stress-relieved in an electrically heated "top hat" furnace. In the foreground of Fig. 5 there is such a strake ready to be placed in the furnace to the left of it. The welding pit and the gantries straddling it can be seen in the centre of the picture.

To the left of the pit is one of the cone ends of the boiler shell. These ends are built up of petal-shaped segments hot-pressed from 3⅜in plates and normalised. All welding is by hand both externally and internally and is carried out as a series operation. After completion of welding and radiographic examination the cone ends are transported to a stress relieving furnace.

The main items of plant for which International Combustion, Ltd., is responsible are : twelve boilers ; main gas ducting between reactor vessels and boilers ; biological shield cooling system, consisting of vertical double skin, bottom ring main, bottom pass steelwork, top pass steelwork, external inlet ducting, extraction ducting and cooling sleeves and pressure vessel cooling hood ; reactor pressure vessel attachments including standpipes and ducts for debris removal, thermocouples and burst slug detection ; carbon dioxide storage vessels and filter vessels ; mortuary tubes and various fabricated items.

Continuous Casting and Rolling Line for Aluminium

Close co-operation over a number of years between Aluminium Laboratories, Ltd., Banbury, and Albert Mann Engineering Company, Ltd., Basildon, Essex, has resulted in the design of a very versatile continuous casting and rolling line for aluminium. Complete plants have been installed in America and Holland, casting machines are in use in Ireland and Hong Kong, and negotiations are in hand for further installations in various parts of the world.

THE Albert Mann Mk. 3 casting machine is the basis of the casting and rolling lines which are installed at the Extrusion Development Corporation, Hawthorne, New Jersey, U.S.A., and Lips, N.V., Drunen, Holland, but the complete lines, though similar, are designed for different products. The Mk. 3 casting machine is available in four standard sizes ; No. 1 for strip between 4in and 8in wide, No. 2 for 8in to 12in, No. 3 for 12in to 16in, and No. 4 for strip up to 20in wide. A larger machine can be used to produce smaller strip, but for each width a separate casting wheel is necessary, to ensure that the strip is fed in a straight line to the edging rolls and the mill proper.

Item	American Line	Dutch Line
Furnaces	One off—6,000 lb per hour Sklenar furnace without holding furnace, gas fired	One off—6,000 lb per hour Sklenar furnace without holding furnace, oil fired
Casting machine	One off—$\frac{1}{2}$in by 8in, mean casting speed 15ft per minute	One off—$\frac{1}{2}$in by 9in, mean casting speed 15ft per minute
Rolling mills	Two off—two-high hot rolling mills in tandem, roll dimensions 12in by 12in	One off—combined two-high hot and cold rolling mill. Roll dimensions 12in by 12in Two off—four-high cold finishing mills in tandem. Roll dimensions 5in by 12in by 12in
Flying shear	One off—hydraulic	One off—hydraulic
Coilers	Two off—20in drum diameter 46in coil o.d.	Two off—12in drum diameter 40in coil o.d. in the hot line One—20in drum diameter 40in coil o.d. in the cold tandem line
Installed kW total	200kW	300kW

Determination of casting machine size is a matter requiring careful consideration of output requirements, as capital costs rise rapidly with increase in width ; larger rolling mill equipment is also needed with the bigger casting machines, and this, too, naturally increases the cost. The American line was installed for the production of strip for slugs for use in making collapsible tubes and aerosol cans, while the Dutch line was designed primarily to supply strip to a tube-forming mill, with narrow strip down to 0·010in thick and slug materials as alternatives. There are, therefore, differences in the two lines, the basic details of which are shown above.

Casting Machine

The main difference between this casting machine and previous models as well as most of the other well-known types of rotary casting machines is that the casting wheel itself is not keyed on to the shaft, but rotates on a stationary shaft of such large diameter that deflection is almost non existent, the wheel being driven by a rim drive. This drive to the rim is taken through two worm reductions which can be set to obtain minimum back-lash. Back-lash in the pinion and the internal gear of the rim drive can be taken up by adjusting an eccentric bush in the hub of the wheel itself. This design guarantees absolutely smooth running, eliminating shudder or vibration at the periphery of the casting wheel due to magnified torsion in the rotating shaft or to back-lash in the driving elements.

The endless mild steel belt which covers the mould groove in the circumference of the casting wheel is now led over four idle rollers instead of three as on previous machines. This has the following advantages:

(1) Above and beneath the casting wheel the mild steel belt runs horizontally which leaves more room for locating the tensioning arrangement (the belt is tensioned pneumatically) on the front pulley and stronger and more efficient outboard bearings can be adopted. Allowing the upper portion of the belt to run horizontally makes it possible to mount a pneumatic cylinder behind the top front pulley which applies pressure to this pulley, so pressing the mild steel belt constantly on to the casting rim at the point where metal is poured into the wheel.

(2) The total height of the machine can be kept lower by adopting smaller diameter pulleys. This means that the foundation costs are reduced as the machine does not need to be mounted in a pit.

(3) The drying section between the back bottom and back top pulleys is now vertical which simplifies to a great extent the mounting of the belt dryers.

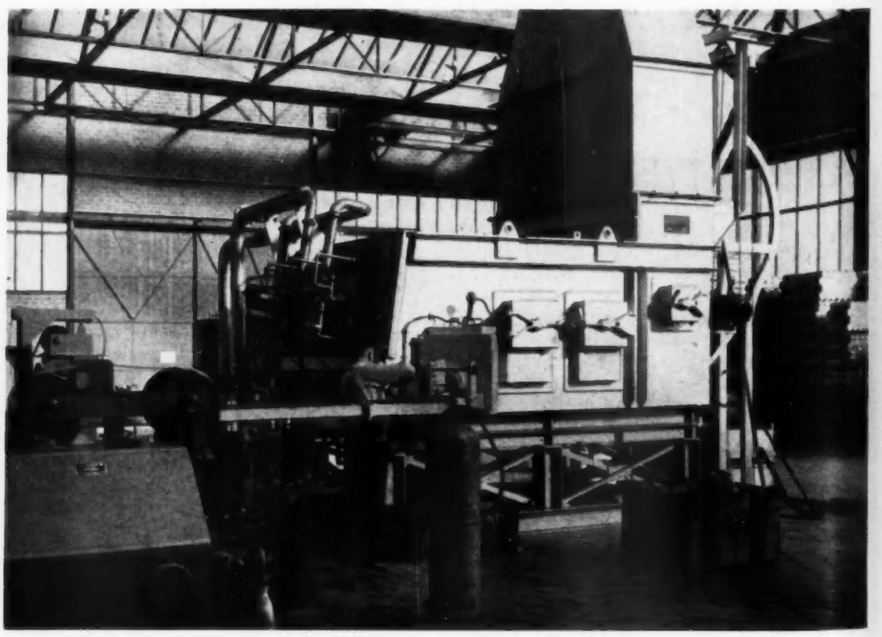
(4) All free running parts of the belt have been shortened which reduces to a great extent the unavoidable buckling of the belt due to the constant change in temperature.

Tensioning of the belt, pressing it on to the casting rim and lifting it for belt changes are done pneumatically. All belt pulleys are equipped with outboard bearings, so guaranteeing parallel running of the belt. All the outboard bearings are, however, designed in such a manner that they are placed within the track of the belt and form no obstruction when the belt requires changing. The casting machine is driven by a 5 h.p. d.c. motor with a constant torque range of 4 to 1. The control desk is placed close to the casting wheel, giving the operator unobstructed visibility of the metal pool. A " Perspex " wall protects the operator from metal splashes. Electric controls are mounted separately from the pneumatic valves and are clearly defined, but in easy reach of the operator.

American Line

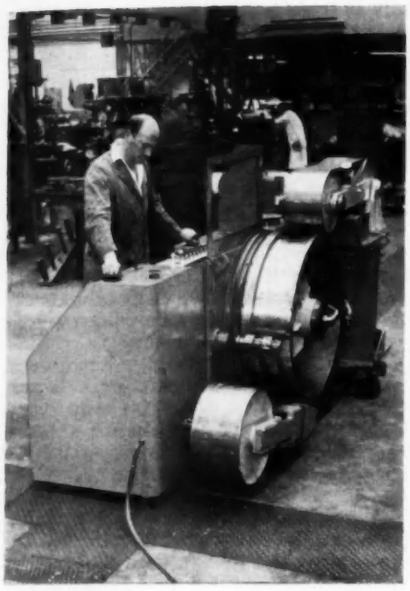
Both rolling mills are identical, differing only in the rolling speed, as they run in tandem. Speeds are matched with the reductions and the screwing speed of the electric screwdown of the second mill is slower than on the first mill, so allowing a finer adjustment on a thinner strip. When designing the mills conventional rules could not be adopted and new ways and means had to be found in many cases to meet the required characteristics of the lines. As the rolling mills have to match the mean casting speed of approximately 15ft per minute, they are very slow running, but their driving elements have to transmit considerable torques due to the high reductions. (The maximum reduction in one pass is 66 per cent.) This is one of the reasons why special needle roller bearings have been chosen as roll neck bearings, which allow a neck diameter of approximately 67 per cent. of the barrel diameter. For cooling and lubricating purposes the bearings are supplied with cooled and filtered oil by an oil circulating system.

A soluble oil circulating system with a capacity of approximately 80 gallons per



Melting furnace ; pouring spout on left

minute feeds coolant to both rolling mills. In the tank, which has a capacity of approximately 1000 gallons, the coolant is kept automatically to a constant temperature by means of thermostatically controlled immersion heaters. Coolant is sprayed not only on to the roll surfaces but is also fed into the bored rolls themselves and into the chocks, which are equipped with internal cooling ducts. This helps to a great extent to keep the temperature of the bearings and roll journals constant thereby avoiding variations in bearing clearances, which again reduces wear and increases the accuracy of the strip.



Casting machine shown during shop erection, the casting wheel is clearly visible

The cross-sectional area of the mill frames is far in excess of that required by the separating force, so that temperature variations in the strip (which should be avoided as far as possible) do not result in uneven stretching of the posts, which would result in an inaccurate strip.

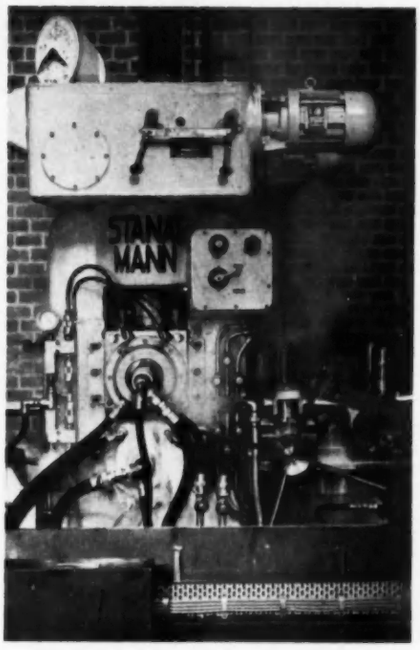
The rolls can be adjusted electrically on the first mill stand at a speed of 2in per minute, on the second at 1½in per minute. Normally, they are only adjusted during the start-up period of the line and until all varying factors have been stabilised. The most important of these variables are the heating up of the rolls, the amount of coolant and the adjustment of the two reductions in order to get a well-balanced loading of the two mills.

The two frames of each rolling mill are connected at their heads by bridge pieces which increase the rigidity of the mills and at the same time provide adequate space for mounting the hydraulic roll-balancing cylinders. These balancing units keep the top chocks constantly pressed up against the setting screws during lifting or lowering. This design obviates the removal of clamps, or unscrewing of bolts or pressure oil connections, so that a roll change can be done in the shortest possible time by the mill operators themselves.

A pair of horizontally-adjustable edging rolls is mounted on the entry side of the first rolling mill to roll the slightly-tapered edges of the cast strip, so giving the strip a rectangular shape and reducing it by approximately ¼in in width. This edge rolling is important as it helps to avoid edge cracking during subsequent rolling processes. A second pair of edging rolls placed further away from the mill guide the strip, and horizontal hydraulically operated pinch rolls prevent buckling of the strip between the edging rolls.

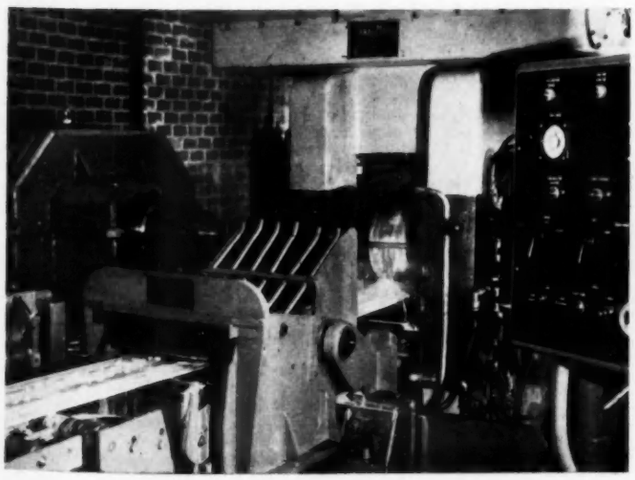
On the exit side of the first mill a hydraulically operated flying shear is mounted to cut the strip as soon as it has been coiled to the required coil diameter. The shear is operated automatically by means of solenoid valves which receive their signal from the adjustable contact rollers on the coilers. As the shear is a very important part of the continuously working line, special care was taken to ensure that safe and faultless operation is maintained under all prevailing circumstances. The operating speed of the shear is in fact variable over the full range of speeds of the rolling mill and can be adjusted down to the casting speed. When working under normal circumstances the shear makes one cut and then returns to its rest position. For safety reasons, however, the shear can be switched to continuous operation, whereby the strip coming out of the rolling mill is cut up into short pieces, during which time any hold-up that might occur between the mill and coilers can be cleared without interrupting the continuous casting process. Mechanically and hydraulically the shear is strong enough to cut ½in cast aluminium strip, should it for some reason or other pass the rolling mill without any reduction, this being the reason why the speed of the shear can be adjusted down to casting speed.

The first rolling mill is driven by a 75 h.p. d.c. motor with a constant torque range, through a double reduction gear (first reduction worm, second double helical), pinions and heavy universal joints. Rolling speed is infinitely variable up to 60ft per minute. The second rolling mill is identical with the first one, so reducing the initial cost, and cost of spares such as rolls, bearings, and seals. This mill is also driven by a 75 h.p. d.c. motor with the same characteristics. The reduction gearbox is, however, designed for a maximum speed of 90ft per minute.

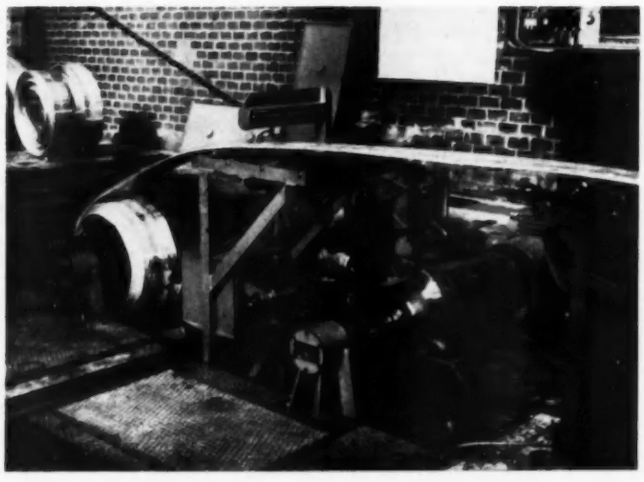


Two-high hot mill with edging rolls (right)

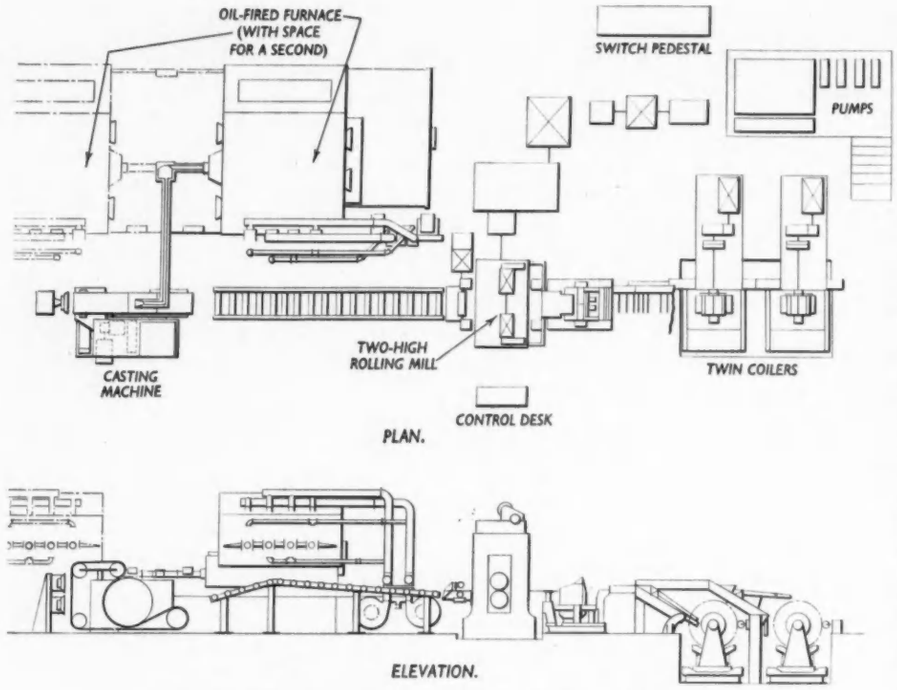
On the exit side of this second mill, the strip is guided by a system of gates and roller tracks to the twin coilers. When one coil has reached its required diameter, the strip is cut by the hydraulic shear and as soon as the strip leaves the second rolling mill the coiler automatically accelerates as the strip tension is reduced. By this method a gap is formed between the end of the first coil and beginning of the following strip which allows the gates to perform their movements in order to guide the next strip on to the second recoiler. Each coiler is driven by a 10 h.p. d.c. motor with a constant horsepower range of 3 to 1.



Hydraulic flying shear on exit side of rolling mill



Twin coilers, No. 2 coiling, No. 1 ready to take over



Layout of casting and rolling line for strip 350mm wide

The driving motors of the casting machine, the two rolling mills, and the two coilers are supplied by one generator set and are electronically controlled. The coolant circulating system, the hydraulic power station as well as the roll neck lubricating system are interlocked with the main drives. To avoid the possibility of the strip tearing or being pulled out of the casting wheel due to inattention of the operator, the strip is fed in a loop over a counterbalanced bridge piece between the caster and the rolling mill. This bridge piece operates a potentiometer which in turn regulates the rolling mill speed. Between the two rolling mills a very slight continuous loop is maintained which synchronises the speed of the second stand with the first stand should speed changes occur due to reduction adjustments. As the coilers work with constant tension they automatically follow every variation of the rolling speed.

The melting furnace has a capacity of 6000 lb per hour and theoretically the line can be operated continuously as the furnace can be charged during the pouring operation. Sklenar furnaces are exceptionally suitable for this type of operation as it is possible to pour direct from the furnace without using a holding furnace which simplifies and cheapens the installation considerably. If it is intended, however, to run the line on a fully continuous basis, then it is always advisable to use two furnaces and pour from them alternately. For the time being the American line has been equipped with one furnace, but during erection the space has been reserved for the installation of the second furnace at a later date. Considering, however, the capacity of such a line, it will be appreciated that demand does not very often require the full output. Taking $\frac{1}{2}$in by 8in aluminium cast strip and a casting speed of 15ft per minute the output would be approximately 6000 lb of finished slug stock per hour.

Dutch Line

This line was mainly designed for more moderate European conditions and was laid out for present demand only with the possibility of increasing the output by adding on units at a later date. As the European wage structure is so different from that in the U.S.A., the labour saving features of this line are not as pronounced as on the American line. Automatic operation has been introduced only where it is essential for the quality of the strip or for continuous and absolutely safe working of the installation. For instance, the automatic feeding of the strip into the coilers was not adopted here, as the strip is coiled after one reduction in the first rolling mill, and therefore only runs at half the speed. Feeding of the strip into the coilers is left to an operator, as in any case one man has to be available for removing the coils. At present the line consists of one 6000 lb melting furnace, one rotary casting machine, one rolling mill, a hydraulic shear and two coilers. In addition, and separate from this unit a two-stand, four-high tandem mill has been installed as a finishing mill and there is one rotary gang slitter for further processing.

As the strip produced on this line is not used mainly for slugs, but forms mostly stock for other products, the cold reduction has to start after one hot rolling pass. For this reason the rolling mill was designed in such a manner that it can be converted very quickly into a cold breaking down mill. Present output requirements permit cold breaking down passes on the same rolling mill, while the casting machine is not in operation. Incidentally, while the rotary casting machine is not in use the furnace feeds a semi-continuous billet casting machine, so that the furnace operators are continuously engaged.

Converting the hot mill into a cold mill takes approximately two hours. The complete set of hot rolls is withdrawn from the frames and replaced by a set of cold rolls. The uncoiling box with roller leveller, which, during hot operation, is covered by the roller table, is uncovered simply by removing the swivelling portion of the roller table, and a sleeve is mounted on the drum of the front spider coiler. As this work has only to be carried out approximately once a month by the mill operators themselves to achieve the present output programme, the required time of two hours has little effect on the economy of the line.

Strip which has reached its final gauge after one or two cold breaking down passes, that is, any gauge down to 0·100in, is removed from the line and forms the stock for the blanking presses for slugs or for the tube welding line. All other strip receives its normal heat-treatment and then further reductions on the tandem cold line.

When at a future date increased output is required a further furnace will be installed and a separate cold breaking down mill will be erected behind the coilers of the hot mill. The complete set of rolls including chocks and bearings is already available for this second mill. The pay-off box with the roller leveller will be moved from the entry side of the hot mill to the entry side of this new cold breaking down mill. To increase the output of narrow thin strip on the tandem line, a third stand would be added between the second stand and the coiler. All the necessary foundations for the second stage have been laid at the same time as foundations for the first erection stage, so that at the later date, when the extension takes place, the production only needs to be interrupted for a very short time and no earth moving will be needed. The electronic control gear for the tandem mill has been designed in such a manner that the controls for the third stand can be included with the least possible cost and labour.

The output of the complete installation is very difficult to determine as it depends largely on how much of the strip can be regarded as finished after the first or second cold reduction and how much of the strip has to be rerolled. It is recognised, however, that the described extensions can double the output of the present line with very little additional capital expenditure.

A strip width of 9in was chosen for this casting line to produce a finished edge trimmed strip of 8in. Naturally any narrower width than 8in can be slit on the rotary slitting line to suit all requirements of the tube welding installation. As the casting process is continuous, any size of coil can be produced, but when determining the size of coil, it has to be decided whether the advantages of a large coil in fact justify the higher expense of the complicated coiler drives and annealing plant. In this line a diameter of 40in has been chosen as this size coil only requires coiler motors with a constant horsepower range of 2 to 1 on a 20in drum diameter and gives very reasonable running times on the tandem mill where the second stand runs at a maximum speed of 900ft per minute. The actual running time and rolling speed result in a very good loading factor of this mill. After adding a third stand to this tandem mill the loading figures will be even better.

Provision for Safety Harness.—The British Motor Corporation, Ltd., has standardised in all its passenger cars three safety harness attachment points for each front seat ; the anchorages are one on the propeller shaft/exhaust pipe tunnel, one in the door sill, and one on the door pillar (if fitted) or the rear wheel arch. The anchorages are particularly adapted to the harness combining a lap strap and a diagonal sash made by Britax (London), Ltd., Byfleet, Surrey. For current production models already completed, kits containing belts, attachments and reinforcing plates are to be made available.

Motor Vehicle Statistics.—The June, 1961, *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., includes figures for the output of vehicles by the main producing countries over the first three months of 1961. This country remained the largest manufacturer of lorries, 4895, compared with 4162 in U.S.A.) and the second largest manufacturers of goods vehicles (119×10^3, compared with 119×10^4 in U.S.A.), but became the fourth largest producer of cars with 218×10^3 fewer than those of U.S.A., Western Germany and France.

Off-the-Road Locomotion

By R. M. OGORKIEWICZ, M.Sc. (Eng.), A.M.I.Mech.E.

No. II (*Continued from page 4, July 7*)

The First International Conference on the Mechanics of Soil-Vehicle Systems was held in Italy from June 12 to 16, and some of the papers presented there were reviewed last week. The second part of the review, which follows, covers a further selection of papers, concerned principally with the prediction of vehicle performance off the road.

FROM the automotive point of view, the ultimate object of determining the Bekker soil values, which were described in the first part of this review[1], or any other soil parameters, must be to establish relationships between the behaviour of vehicles and their environment. To achieve this object requires not only experimental soil data but also series of equations which would relate vehicle behaviour to the characteristics of the soil. Several of these were given by Bekker in his original comprehensive volume[2]. Since its publication the mathematical models of soil-vehicle relationships have been refined further at the Land Locomotion Laboratory of the U.S. Army Ordnance Tank-Automotive Command. An example of this work was given by Z. Janosi and B. Hanamoto in their paper on "The Analytical Determination of Drawbar Pull as a Function of Slip for Tracked Vehicles in Deformable Soils." In their analysis, the authors obtained a simpler equation for the thrust available in any given soil than that obtained by Bekker[3] by observing that experimental soil shear stress-strain curves could be described by the following equation,

$$s=(c+p\tan\phi)\left(1-e^{-\frac{j}{K}}\right) \quad . \quad . \quad (1)$$

where j is the soil deformation in the horizontal direction. The total tractive effort H of a tracked vehicle can then be obtained by integrating the shear stresses along the ground contact area. In the case of uniform pressure distribution, i.e. p=constant, this yields the following result. It should be noted that soil deformation under a track is proportional to the distance x of the soil particle from the front end of the soil-vehicle interface, the factor of proportionality being defined as the slip i_o,

$$H=(Ac+W\tan\phi)\left[1-\frac{K}{i_o l}\left(1-e^{-\frac{i_o l}{K}}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad (2)$$

since $j=i_o x$. In the case of tracks with grousers, the additional thrust which they produce may be calculated by means of an equation established by Bekker[4].

To obtain the net tractive effort, or drawbar pull DP, it is necessary to subtract from traction the resistance to motion, i.e.

$$DP=H-R \quad . \quad . \quad . \quad . \quad (3)$$

where R is the total resistance to motion, arising from several causes. The authors only considered the resistance due to compaction R_c and used the expression proposed by Bekker[5], which for a single track is

$$R_c=\left(\frac{\overset{o}{K}_c+b\overset{o}{K}_\varphi}{n+1}\right)Z^{n+1} \quad . \quad . \quad (4)$$

where

$$Z^n=\frac{P}{\left(\frac{\overset{o}{K}_c}{b}+\overset{o}{K}_\varphi\right)} \quad . \quad . \quad . \quad (5)$$

For the more involved case of sinkage linearly proportional with x, equation (5) was also used to express pressure as a function of sinkage Z and a solution was obtained by means of a power series.

The corresponding case of wheeled vehicles was tackled by Z. Janosi in "An Analysis of Pneumatic Tyre Performance on Deformable Soils." The starting point was again provided by the basic relationship given by Equation (5) and the related expression for sinkage Z_o derived by Bekker[6] and already quoted in the first part of this review. From these premises the author derived an expression for the resistance to motion of a rigid towed tyre, which is given below, the first term on the right hand side representing the resistance due to the vertical components of pressure and the term that due to the horizontal components,

$$R=(k_c+bk_\varphi)\left[\frac{Z_o}{n+1}^{n+1}\left(1-\frac{Z_o}{\frac{D}{2}(n+2)}\right)\right]+\int_{D/2-Z_o}^{D/2}y^{n-1}\left(1-\frac{\frac{D}{2}-Z_o}{y}\right)^n\left[\left(\frac{D}{2}\right)^2-y^2\right]^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where y is the vertical distance between wheel centre and a point on the perimeter.

In the case of a soft towed tyre, the sinkage will result in a ground pressure which is the sum of the tyre inflation pressure p_i and that due to the stiffness of the carcass p_c, i.e.

$$p=p_i+p_c \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Substituting this in Equation (5) and using the result in conjunction with Equation (4) on the assumption that the tyre-ground interface is flat, one obtains

$$R_c=\frac{b}{n+1}\left(\frac{k_c}{b}+k_\varphi\right)^{-\frac{1}{n}}(p_i+p_c)^{\frac{1+n}{n}} \quad . \quad (8)$$

To this one must add the component of resistance due to the flexing of the carcass, which for a typical 14/20 tyre was given as

$$R_d=W\left[0{\cdot}0225-0{\cdot}025\log\frac{p_i}{40}\right] \quad . \quad (9)$$

Adding R_c and R_d, to obtain the total resistance, it is obvious that the component of resistance due to soil compaction is proportional to inflation pressure whereas that due to carcass flexing is inversely proportional to it. The total resistance will, therefore, have a minimum value at an optimum inflation pressure p_{io}, which in this particular case was given by the following relationship

$$(p_{io}+p_c)\frac{n}{p_{io}}=\left(\frac{k_c}{b}+\overset{o}{k}_\varphi\right)\left(\frac{0{\cdot}0108nW}{6}\right)^n \quad . \quad (10)$$

This shows clearly that the optimum inflation pressure depends on the soil as well as the carcass of the tyre.

Another useful notion presented in the paper was that of the critical inflation pressure above which the tyre may be considered to behave as a rigid wheel and which was given as

$$p_{i\,crit}=\frac{(n+1)W}{b\sqrt{DZ_o-Z_o^2}} \quad . \quad . \quad (11)$$

Finally, the author considered the question of drawbar pull of a rigid driven wheel and on the basis of Equation (1) derived an expression of moderate complexity but inordinate length which, like other equations established at the Land Locomotion Laboratory, has been programmed on a Datatron 204 electronic computer.

Both papers provided some comparisons between theoretical results and experimental observations. In the first case this involved small scale models of tracked vehicles and in the second case single full-size towed wheels. In both cases sand and farm soil were used and reasonable agreement was obtained between theory and experiment. However, a much more interesting comparison between theory and experiment was presented by W. L. Harrison in the "Analytical Prediction of Performance for Full Size and Small Scale Model Vehicles," also based on work at the Land Locomotion Laboratory. The predictions were based on the equations given in the previous two papers and the vehicles considered were a Caterpillar D4 tracked tractor, Ford 601 wheeled tractor and the M43 4×4 truck, and their quarter-scale models. In the case of the D4 tractor bulldozing resistance[7] was taken into account in addition to compaction resistance and as the sinkage was small Equation (2) was used to calculate the thrust. For the two wheeled vehicles the equations used were those given in Janosi's paper for towed and powered rigid wheels, but for the rear wheels the horizontal component of the resistance to motion was ignored on the assumption that they operated in ruts made by the front wheels, and the change in axle loads due to drawbar pull was taken into account. The full size vehicles were tested in soil bins 120ft long, 12ft wide and 4ft deep; the quarter-scale models were tested in smaller soil bins whose corresponding dimensions were 30ft, 4½ft and 1½ft. In both cases two types of soil were used, a dry sand and a sandy loam typical of Michigan farm soil and maintained at a moisture content of 20±1 per cent. Soil values were obtained by means of a Bevameter and in the case of the sandy loam were analysed statistically, so that the maximum and minimum soil values used in the calculations covered a range representing approximately 90 per cent of the observed soil parameters. In consequence, the calculated results gave a band instead of a single curve of drawbar pull v slip. In the case of the dry sand statistical sampling was not used, because variation in soil values was negligible, and consequently a single curve was obtained.

The actual soil values are tabulated below and the calculated results for full size vehicles are given graphically in Figs. 1, 2 and 3, together with the experimental results.

Bekker soil values	Sandy loam		Dry sand
	Minimum	Maximum	
k_c	8·6	11·1	0·05
k_φ	4·85	6·46	3·58
n	0·680	0·786	1·18
c...	0·25	0·34	0·10
φ	35·5 deg.	37·0 deg.	28·0 deg.
K	0·1	0·1	0·31

There is no sand performance graph for the M43 truck since this vehicle was unable to negotiate the dry and very loose sand because of its relatively small tyres and of the load per wheel. Similar results were obtained for the quarter-scale models and again the M43 truck was unable to negotiate the dry sand.

In general, the results indicated that the methods of prediction developed at the Land Locomotion Laboratory on the basis of the Bekker soil value system are equally

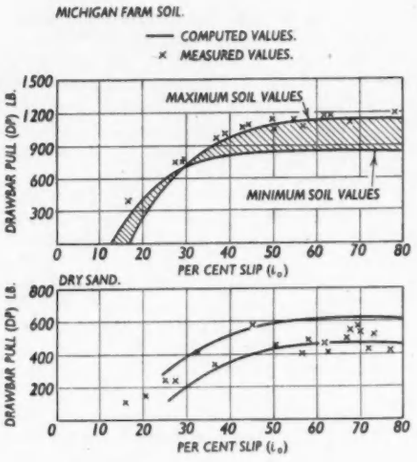


Fig. 1—Drawbar pull v slip for Ford 601 wheeled agricultural tractor

applicable to full-size vehicles and models and for homogeneous soils are accurate to within 10 per cent. Further studies are now proceeding of the changes in soil values with deformation caused by the passing of a wheel or track, the effect of slippage on sinkage and motion resistance and of multi-layer soils, and it is hoped that they will improve the accuracy of prediction beyond the present 10 per cent.

Model Studies

The alternative, or supplementary, approach to the prediction of full-size vehicle performance by extrapolation from model tests was given in " Scale Models of Vehicles in Soils and Snows " by C. J. Nuttall and R. P. McGowan. This paper, based on work sponsored by the U.S. Army Transportation Corps, deserves attention not only because of its subject matter but also because one of its authors, Nuttall, had largely initiated the dimensional analysis of cross-country vehicle performance.

For sands, dry snows and other primarily frictional materials, dimensional analysis has led the authors to the following equation for drawbar pull

$$DP = W \oint, \left(\frac{W}{Cd^2}, \phi, i, \frac{h}{d}\right). \qquad (12)$$

where d is a characteristic linear dimension of the vehicle, such as its wheel diameter, i is the slip, h is the depth of the soil material considered and the other symbols as already defined. For terrain where the internal friction is substantially constant with depth, the problem of correlating scale model and full-size results reduces itself to evaluating the load numeric W/cd^2, and consequently to the value of the cohesion c for the strata affected by vehicle motion. This was resolved by assuming that in tests with two different size plates the penetration, given by the equation

$$Z = df_2\left(\frac{p}{c}\right) \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where p was the average penetration pressure, could be correlated if appropriate values of c were known. Relative values are sufficient for this purpose and it was further assumed that they could also be used in the load numeric describing the results of tests on other scale models and full size objects in the the same scale ratio as the two plates, provided that the test plates had sampled the terrain to the same general depth as their respective counterparts. A unit value was arbitrarily assigned to the average cohesive strength experienced by a 12in diameter plate and for other diameter plates the relative strength c_r was obtained by correlating their penetration pressure results with those of the 12in plate. Thus, full-size prototype

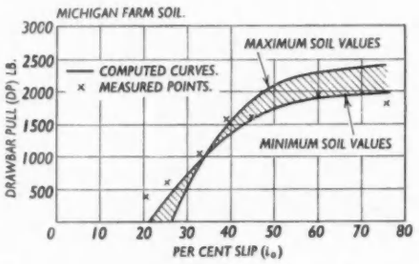


Fig. 3—Drawbar pull v slip for the 4×4, ¼-ton M43 truck

tests were conducted in snow on the assumption that it had an average $c=1$, while tests on a quarter-scale model were carried out assuming that the snow had a $c_r=0{\cdot}32$, which was the value giving the best correlation between a 3in plate and the 12in plate.

Derived for snow, the method has been extended to sand performance and the results of a large number of tests on different 4×4 vehicles, carried out in 1957 to 1959 in snow and sand, are shown in Figs. 4 and 5, where the ratio of drawbar pull to weight is plotted against the load numeric W/c_rbd, b being the overall tyre width and d its outside diameter. The tyre sizes covered in the tests ranged from 24in to 120in o.d., the large tyres being the result of Transportation Corps' concern with such giant vehicles as the Logistical Cargo Carrier for Arctic operation ; loads per tyre range from 50 lb to 3000 lb in snow and up to 50,000 lb in sand. To use the results presented in the two figures in design work it is essential to know c_r for different conditions : for snow, it was stated, $c_r=d_p/12$ and for sand it was suggested $c_r=d_p/6$, where d_p=diameter of plate in inches.

Dimensional analysis is also being pursued at the University of Michigan. However, the results reported by H. H. Hicks in " A Similitude Study of the Drag and Sinkage of Wheels Using a System of Soil Values Related to Locomotion " did not bring out any particularly significant points, except to stress the importance of the ratio of soil

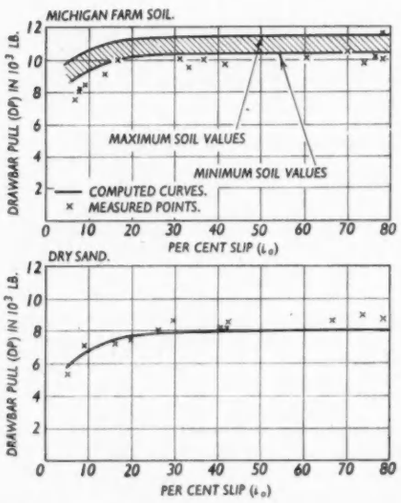


Fig. 2—Drawbar pull v slip for Caterpillar D4 tracked tractor

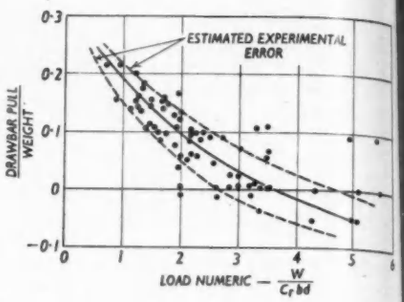


Fig. 4—Performance of 4×4 vehicles in dry sand

depth to wheel diameter, which must be taken into account in the correlation of experimental results.

Scale models of earth moving tools are used by the Caterpillar Tractor Company, as reported in " Scale Model Evaluation of Earthmoving Tools " by D. E. Cobb, G. T. Cohron and J. D. Gentry. Their scale ranges from one-fifteenth to one-eighth and they are tested in well-instrumented bins with artificial soils made up of fire clay, sand and low viscosity oil. The results were said to indicate that earthmoving processes are well suited to scale model investigations but virtually none were given and the paper confined itself to a general description of the test equipment.

Statistical Analyses

Most of the investigations into the behaviour of off-the-road vehicles, including those reported in the above papers, assume or imply flat terrain so that the geometry of the ground surface is not involved. In fact, of course, off-the-road surfaces are generally rough and this limits the operational speed of vehicles, quite apart from the physical characteristics of the soil, because of the vibrations induced in them. It is necessary, therefore, to study the geometry of the ground surface and its effect on vehicle behaviour.

The irregular nature of the ground roughness has prompted a statistical approach to the problem presented in two papers by J. L. Bogdanoff and F. Kozin, of Purdue University. One, " On the Statistical Properties of the Grand Contour and its Relation to the Study of Land Locomotion," dealt with the statistical description of ground roughness and in particular with an analytical model of a random surface defined in terms of its power spectrum). The paper also described a survey, sponsored by the Land Locomotion Laboratory and believed undertaken for the first time in the United States, to determine the nature of real ground spectra. The second paper, " On the Statistical Analysis of Linear Vehicle Dynamics," concerned itself with an idealised two-dimensional linear vehicle moving with constant horizontal velocity on a second order, weakly stationary and mean-square continuous random track with contact maintained at all times between the idealised tyre and the track. One practical

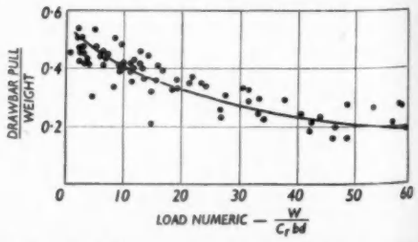


Fig. 5—Performance of 4×4 vehicles in dry beach sand

conclusion of this promising if very involved line of attack is that wheelbase has a pronounced effect on vehicle ride but considerable further effort appears necessary before the proposed approach can be fully justified and put to practical use.

Another application of statistical methods was illustrated by M. G. Bekker, now head of the Land Mobility Laboratory of the General Motors Defence Systems Division, in his paper on the " Evaluation and Selection of Optimum Vehicle Types under Random Terrain Conditions." Since terrain characteristics change with geographical and climatic conditions, the author rightly stressed the need for a statistical approach to the selection of off-the-road vehicles, such as tractors, so that the probability with which they can achieve a certain level of performance in a changing environment can be evaluated and, consequently, optimum types can be selected from among possible designs or available models. Such an approach would lead to a saving in national economies and would be of particular interest to the so-called underdeveloped countries, which must choose the most economic vehicles.

The basis for such an approach is provided by Bekker's soil values system and an empirical correlation of the soil values with the moisture content of a given soil, as shown in Fig. 6 for a typical homogeneous sandy loam. Thus, knowing the variation in the moisture content due to weather cycles, it is possible to define the variation in soil values. Representative time variation in moisture content at a depth significant in locomotion problems is shown in Fig. 7, based on measurements obtained in Middlesex by the Road Research Laboratory, and from such observations one can derive the frequencies of moisture content percentages and the probability density curve. In doing this the author eliminated measurements taken during the three summer months, shown shaded in Fig. 7, on the assumption that low moisture contents, below about 15 per cent, produce a hard surface soil and do not affect performance.

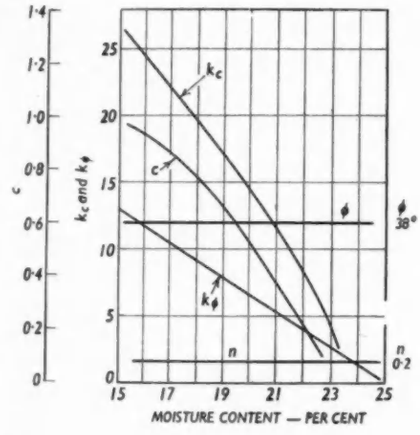


Fig. 6—Variation of soil values with moisture content for homogeneous sandy loam

From these premises and using an appropriate mathematical model of a soil-vehicle relationship, it was shown that, for instance, curves of drawbar pull *v* ground pressure could be calculated for various probabilities of success, i.e. that one could calculate the lowest value of drawbar pull which, for a given ground pressure, may be encountered with a particular probability in the considered area and weather cycle. Finally, taking a drawbar pull to weight ratio representing a desired level of vehicle performance, the author obtained the ground pressures necessary to achieve it and the related probabilities. Thus, in the case considered, selection resolved itself to the acceptance, or otherwise, of a particular ground pressure, which implied a definite tractor model and cost and a certain probability of achieving the assumed level of performance. Similarly, other aspects of vehicle performance could be expressed as a function of various design variants and probabilities of success.

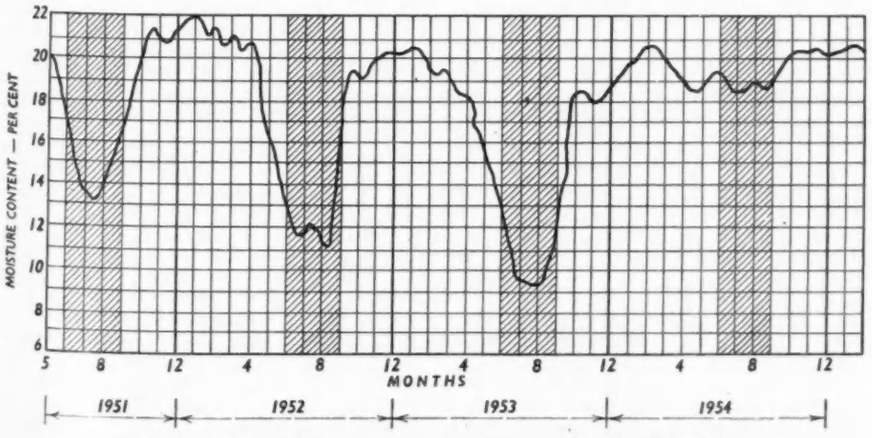


Fig. 7—Variation in the average moisture content at a depth of 1ft to 2ft

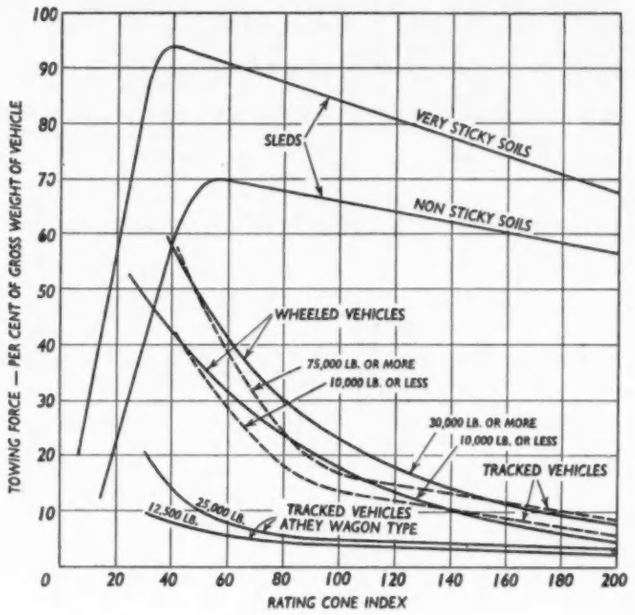


Fig. 8—Curves of towing force v rating cone index for various vehicles

Trafficability

An entirely different approach to predicting vehicle performance was presented in " Measurement and Estimation of the Trafficability of Fine-Grained Soils " by S. J. Knight and A. A. Rula, of the Army Mobility Research Center, U.S. Army Engineer Waterways Experiment Station. Trafficability was defined as the ability of soil to support the passage of vehicles and the object of the work at the Waterways Experiment Station has been to develop a simple and rapid method of assessing this. The development started several years ago, at the end of the Second World War, and the method was based on the use of a cone penetrometer, a simple rod-like instrument which can trace its ancestry to the Proctor needle and other soil penetrometers used by civil engineers or, perhaps, even to the ash sticks with which the commanders of the early British tanks used to walk and probe the ground in front of their vehicles. The penetrometer is forced by hand into the ground and the required force, which is measured by means of a proving ring and dial gauge immediately below the handle, is divided by the 0·5 square inch base area of the right circular 30 deg. cone at the end of the $\frac{3}{8}$in diameter 3ft long penetrometer shaft, the quotient being called the Cone Index.

The cone penetrometer provides a simple small-scale test which measures a number of fundamental soil properties in unknown proportions. Like the results of other penetration tests, the cone index can be correlated with some of these values or with past experience with vehicles in certain soils. Thus, within limits, it can be used to predict the ability of a vehicle to traverse, or not, a particular surface by comparing its cone index with the cone indices of the soils in which the vehicle was tested. A further example of its use is provided by Fig. 8, which shows curves of the towing force required for different types of vehicles plotted against the cone index, used to classify different types of soil. In essence, the cone index method is based on extensive testing of existing vehicles and is applicable only to these vehicles, or very similar models. It cannot be used to predict with any accuracy the performance of new designs and its arbitrary nature makes it questionable and questioned[9].

Nevertheless, it is claimed that the cone index can be correlated with the general characteristics of vehicles by means of what is called a Mobility Index and the curve shown in Fig. 9.

For tracked self-propelled vehicles the

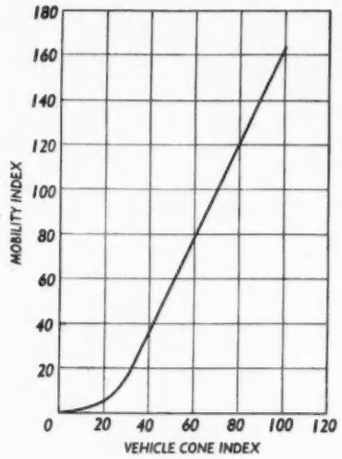


Fig. 9—Relationship between vehicle cone index and the "mobility index"

mobility index is defined by the following formula, whose only justification appears to be that it has been found satisfactory; other formulae have been devised for towed and wheeled vehicles but they have not been fully tested.

$$\text{Mobility Index} = \left(\frac{\text{Contact pressure}}{\text{Track factor}} \times \frac{\text{Weight factor}}{\text{Grouser factor}} + \text{Bogie factor} - \text{Clearance factor}\right) \times \text{Engine factor} \times \text{Transmission factor}$$

where,

$$\text{Contact pressure} = \frac{\text{gross weight in lb}}{\text{area of tracks in contact with ground in square inches}}$$

Weight factor: Less than 50,000 lb = 1·0
50,000 lb to 69,999 lb = 1·2
70,000 lb to 99,999 lb = 1·4
100,000 lb or greater = 1·8

$$\text{Track factor} = \frac{\text{Track width in inches}}{100}$$

Grouser factor: Grousers less than 1·5in high = 1·0
Grousers more than 1·5in high = 1·1

Bogie factor:

$$\frac{\text{gross weight in lb divided by 10}}{(\text{Total number of bogies on tracks in contact with ground}) \times (\text{area of 1 track shoe in square inches})}$$

$$\text{Clearance factor} = \frac{\text{Clearance in inches}}{10}$$

Engine factor:
10 or greater horsepower per ton of vehicle weight = 1·0
Less than 10 h.p. per ton of vehicle weight = 1·05

Transmission factor: Hydraulic = 1·0; Mechanical = 1·05.

A related study at the Waterways Experiment Station was described by S. J. Knight and M. P. Meyer in "Soil Trafficability Classification Scheme." This attempts to identify terrain in terms of its soil type, topography and general wetness level, and the corresponding cone indices which are used to measure the strength of the soils and to predict their trafficability. Since the strength, and hence the cone index, vary, the data were analysed statistically to determine the probability of occurrence of cone indices and, thus, the probabilities of successful traverse by vehicles with a known index. The broad aim of the study, which is to assess terrain from the point of view of vehicle operation, is most praiseworthy but it is questionable whether the cone index provides a sound enough basis for determining trafficability, in spite of the authors' claim that their trafficability classification scheme is feasible, for soils in a temperate climate at any rate.

Some support for the use of the cone penetrometer was provided by three papers presented by the Trafficability Research Team of the Israeli Army's Corps of Engineers. The Israeli Team's work is concerned chiefly with sand and one of the three papers suggested a possible combination between the U.S. Corps of Engineers' cone index methods and the more basic approach of the U.S. Ordnance based on the Bekker soil value system, to overcome the problem of laborious trials necessary to establish the cone index of individual vehicle models connected with the former by using calculations based on the latter, and yet to retain the use of the cone penetrometer because of the ease with which it can be used by units in the field. An example was given for deep loose sand which suggested the possibility of further correlation between the cone index and the Bekker soil values.

However, the experience of the Land Locomotion Laboratory, which had investigated this possibility some three years ago was not encouraging, since it was found possible, in some cases, to predict cone values from Bekker values, but, as might have been expected, it was not possible to predict the latter from the former. The Israeli Team also described a new type of penetrometer which records simultaneously the force required to force a standard cone into the ground and its depth of penetration on a paper attached to a rotating drum which is turned by a string against the action of a spiral spring. Thus, the proposed penetrometer gives records of force v penetration which can be obtained in the field by one man, not necessarily highly trained, and analysed later.

At the same time the penetrometer is sufficiently robust for military use, by reconnaissance parties for instance, and it can be used by night as well as by day.

In the case of organic terrain, such as the Canadian muskeg, analyses still seem confined to qualitative terms illustrated by "Land Factors and Vehicle Design in Operations on Organic Terrain" by N. W. Radforth, of Hamilton College. However, even a qualitative description can be helpful by delineating the principal characteristics and has apparently helped in the development of such special vehicles as the "Musk-Ox" intended for operation in the Canadian North. Some of the development of this interesting articulated tracked vehicle was mentioned by J. G. Thomson, of Imperial Oil, Ltd., in "Vehicle Design from Field Test Data." Apparently, it consisted of a series of field tests with progressively larger vehicles to establish such things as the maximum allowable ground pressure and the optimum position of the centre of gravity but few details were given in the paper and none of the design method, which made use of shear vane values to calculate drawbar pull with what would appear only a moderate degree of success.

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[9] Bekker, M. G., *op. cit.*, page 172.

(To be continued)

OBITUARY

E. L. CADWALLADER

WE record with regret that Mr. E. L. Cadwallader died last Sunday at his home in Ealing; he was a Director of C.A.V., Ltd., having been with the company for fifty years, and having been Joint General Manager from 1933 until his retirement from active executive duties in 1953.

Edmund Latham Cadwallader was born at Compton, Staffordshire, on November 25, 1882, and was apprenticed to Thomas Parker of Wolverhampton, one of the oldest-established electrical concerns; after some time with Eastern, Anderson and Goulden, Ltd., of Erith, and Waygood-Otis, Ltd., he joined C. A. Vandervell in 1911, and was first engaged in the production side of the business. He early turned to sales work, and his main task was to sell electric lighting for both passenger and goods vehicles in place of oil or acetylene lamps; he saw the first dynamo lighting set to be fitted to a public service vehicle installed by the London General Omnibus Company, Ltd. After dynamos came the electric self-starter, and the first geared starter made its appearance in 1917. When the firm was taken over by Joseph Lucas, Ltd., in 1926, Mr. Cadwallader remained at the head of the sales organisation, as he did in 1931, when the company entered the fuel injection equipment field and fused its interests to become C.A.V.-Bosch, Ltd. Two years later he was appointed joint general manager, the position he held until, in 1953, he was appointed consulting director on giving over his more active duties.

Mr. Cadwallader was a member of the Institute of Transport for many years, and served on the Henry Spurrier Memorial Committee.

ALFRED GEORGE COOPER GWYER

WE regret to record the death of Dr. Alfred G. C. Gwyer, B.Sc., Ph.D., F.I.M., which took place on June 27. Alfred George Cooper Gwyer was born in Bristol on October 30, 1880. A graduate of London University, he took his doctorate at Göttingen, Germany, and started work at the National Physical Laboratory, Teddington, in 1911. A year later, Dr. Gwyer joined the British Aluminium Company, Ltd., as a research metallurgist, becoming chief metallurgist in 1920 and scientific manager in 1939. He retired from this position in 1945. Dr. Gwyer was a founder member of the Institution of Metallurgists and an original member of the Institute of Metals, of which he was twice a member of Council and a vice-president from 1931 to 1937. In addition, he was prominently associated at various times with the work of the Welding Research Council, the Institute of Welding, the British Standards Institution, and the British Non-Ferrous Metals Research Association.

Infantryman's Guided Weapon

The one-man anti-tank weapon system initiated by Vickers-Armstrongs (Aircraft), Ltd., has, after several years' development—it was first fired at tanks in 1959—reached the stage of being demonstrated in simulated tactical conditions. Its distinctive virtue is that it is suitable for use by men having only little special training.

IN 1957 Vickers-Armstrongs (Aircraft), Ltd. initiated the development of an anti-tank weapon for infantry use which was intended to be light enough to be carried into action by one man. The demand for small size and weight resulted in a vehicle flying faster than previous weapons of this class, thus increasing greatly the manoeuvreability available and necessary. To render such a high performance controllable by infantrymen not specially selected for the task, the vehicle was given an automatic pilot slaved to rate gyros, so that any command from the operator corresponds to a given (angular) velocity, and not to a (linear) acceleration ; while there is apparently little difference in principle between these control responses, the presence of the auto-pilot allows much higher rates of turn to be controlled. The result is claimed to be that the weapon can engage tanks not only more quickly than other missiles or (allowing for range-finding) guns but also at shorter ranges than other command guided weapons. A further claimed advantage of the auto-pilot of the first importance is that the operator's task is rendered much easier, and that only small numbers of rounds are needed for training and practice.

The configuration of the missile will be familiar (see illustration of " Vigilant " 891 on page 378, September 13, 1957) ; in the case of " Vigilant " 897 the vehicle and container/launcher weigh 44 lb and the guidance unit another 6 lb. For the warhead there is available 36 per cent of the launch weight, closely a stone, but it should be realised that Vickers-Armstrongs (Aircraft), Ltd. offers only the delivery system ; the provision of a warhead is the purchaser's responsibility, and while an armour-penetrating charge is in existence, no " Vigilant " has ever flown with one. The propellant charge is a cigarette-burning double-base (i.e. cordite) casting made by Imperial Chemical Industries, Ltd.; it is smokeless, and supplies not only the nozzle (with an initial peak due to a sharply convex rear face) but also the turbo-alternator and the control surface actuators. A separate small and relatively quick-burning charge spins up the gyroscopes. Finally, a tracking flare is mounted at the propelling nozzle. The vehicle flies at about 500ft per second, and the controls are capable of imposing an angle of attack of up to 30 deg., corresponding to 5*g*. The trailing wire, stowed around the skirt at the tail, is 1700 yards long ; the radio-controlled version originally projected has yet to be built, and the wire-guided round is proposed even for indirect fire controlled from a helicopter.

The motor body forms the main structural member of the missile. The wings are attached to the motor body in four light-alloy wing-root channel sections. The wings are very light and tough, being of foam-filled resin-impregnated glass cloth construction. The low aspect ratio wings were chosen primarily to keep the missile and its container to minimum dimensions and also to minimise the risk of grazing the ground or obstructions such as bushes or branches of trees ; very large incidences can be quickly generated and even at these incidences the low aspect wings do not stall.

The motor gases are ejected rearwards through the axial blast pipe and nozzle. The combined igniter and flare unit is easily fitted to the end of the blast tube in the field. The flare, which is ignited by the temperature of the blast tube makes for easy tracking.

The rear cylinder houses the actuator assembly including the transducers and fin position pick-offs and also the turbo-alternator. The fact that the missile is not roll-stabilised has permitted a simplification in that opposite pairs of control surfaces are mechanically coupled and two actuators only are required.

A V.897 blasts off : notice that the pitch gyro is still caged to give an initial push-over into level flight

The turbo-alternator is speed-controlled to ±5 per cent by a centrifugally-operated brake ; the a.c. output is rectified by silicon-alloy diodes and smoothed.

The wire link carries the up-down right-left demand signals, generated at the sight-controller, to the missile. The link is an insulated cable of four fine steel wires each individually insulated. The cable is wound on a cylindrical spool with a sloping flank at the training edge. A metal shroud is fitted round the spool so that the wire leaves through an annular gap at the periphery of the missile.

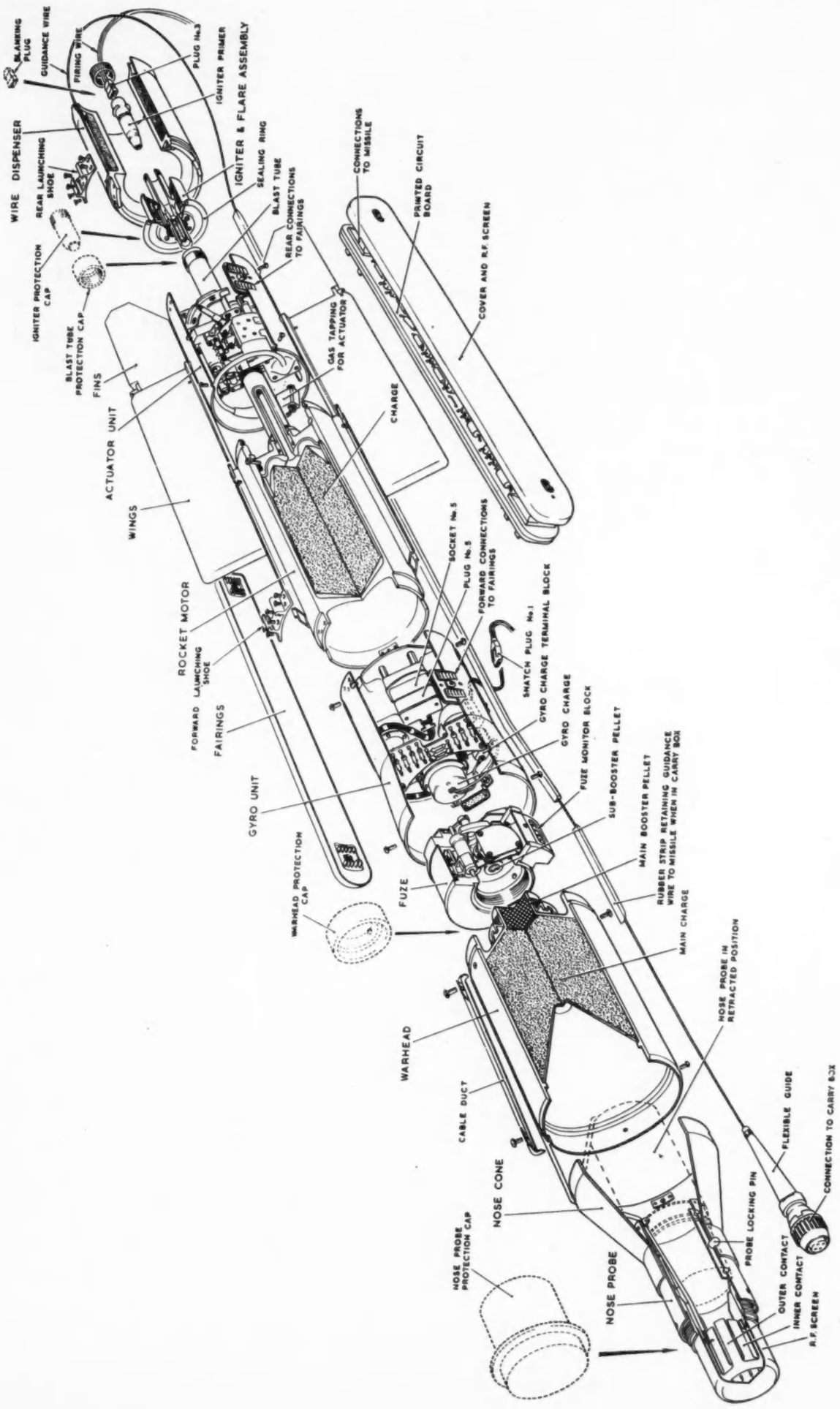
The control system electronics are contained entirely within the two fairing pieces which span the motor section and provide inter-connection at either end of the missile. Silicon transistors have been used throughout for miniaturisation, low power consumption, and operation over a wide temperature environment. Printed circuitry and encapsulation provide a high standard of reliability. The arrangement is particularly favourable for ease of servicing, the operation of two screws only being required to remove or replace a defective fairing. Plugs and sockets at either end make contact with the wiring in the missile.

The missile is packed in a long square box which opens at both ends and also, to give access to convectors, at the sides. The front hinges down to act as a prop, and the rear removes completely, carrying with it the 75ft long lead connecting launcher to controller. When set up, the launcher is prevented from toppling sideways by two lines ending in pegs. The trailing wire is led up to the nose and plugged in to a socket at the front of the box, so that the vehicle is not disturbed by the pull of the wire until it has gained some speed ; the wire is 1700 yards long, the opportunities to engage targets at greater ranges than this being regarded as too few to justify any increase in the weight and cost of the system. The " Vigilant," having no batteries or thermionic valves, has a long storage life without attention and needs relatively little maintenance ; repair is by replacement, complete interchangeability of components being claimed.

The controller takes the form of a stock with two handgrips, one with a trigger for firing the weapon and the other with a thumb cradle for guiding it. Mounted on the controller is a monocular eyepiece of ×5 magnification to allow the missile to be aligned more readily with distant targets ; it will be noticed that, in contrast to the original concept, it is no longer considered that binocular vision is needed to monitor the range and range rate of the target, but it is reported that some even of experienced operators prefer to dispense with the magnification in order to keep both eyes on the vehicle. A switch is provided to command an initial rate of turn to either side, in addition to the initial pushover to level flight, when targets well to one side of the launcher axis are to be engaged.

In a demonstration to invited spectators at the School of Infantry, Warminster, Wilts., last week, two operators were landed from a Sud-Aviation " Alovette " II helicopter, each carrying a " Vigilant " in one hand and a control unit in the other ; the men had opened the carriers, set them up as launchers, guyed them, and connected the control wires ready for firing within seventy seconds. A number of " Centurion " tanks, generally approaching, were then engaged at ranges between 1350 yards and 400 yards ; the overall result was that twelve out of thirteen rounds struck their targets, but in two cases the strikes were glancing and were

ASSEMBLY OF "VIGILANT" V.897



followed by second shots because of the highly directional nature of the shaped charge warhead. The one miss was due to a breakage of a trailing wire, which is found to occur roughly once in 100 shots. It appeared that one at least of the two operators was flying the missiles not along the line of sight, but on to the target in a dive, possibly to obtain a more effective strike on oblique armour. Experience with " Vigilant " shows that there can be expected a missile reliability of 95 per cent and a hit in 90 per cent of the successful firings ; the estimated ratio of kills to firings is 0·6.

Tactically, it will be clear that the possession of a weapon which can go virtually anywhere, even with parachute troops, and which needs no more training than can economically be given to a large proportion of the troops, gives a much enhanced protection against opposing armour. In particular, with such a relatively low-cost weapon it becomes possible to render large areas untenable by armour and thus prevent cavalry exploiting a break-through and inflicting severe damage upon headquarters, depots, workshops and lines of communication.

West Germany Accepts "Blue Streak"

LAST week the Federal German Government made known its willingness in principle to participate in a European organisation for the development of space vehicle launchers in the sense of the Anglo-French proposals issued at the Strasbourg Conference in February, 1961.

The Anglo-French Proposals

A number of European countries were represented at that conference at Strasbourg in February, convened by Britain and France to discuss the feasibility of setting up a European satellite launcher organisation. This would have as its object the development and production of satellite launching vehicles on a European/Commonwealth co-operative basis for peaceful scientific and commercial purposes. The conference took as its starting point a comprehensive Anglo-French proposal for a three-stage rocket incorporating the British " Blue Streak " as its first propulsion stage, a French liquid-propelled rocket as the second stage, and a hypothetical third stage to be built elsewhere in Europe.

The Anglo-French proposals discussed at Strasbourg provided for the setting up of an international organisation to develop and produce satellite launchers, the " Blue Streak " based three-stage launcher being in effect the first programme of the organisation but it being open to it to embark on other projects in the field.

The Form the Organisation Might Take

The establishment of the organisation and the way in which it would work is a matter for the countries concerned. Consultations are now proceeding with a view to convening a conference to draw up a convention and set up the organisation.

The British Government appears to favour some such organisation as that outlined here. The Organisation would be controlled by a governing body on which each of the participating Governments would be represented. Within the framework of the convention the governing body would determine the policy of the Organisation and supervise the agreed programme. It would also decide in which countries the third stage of the launcher and satellite test vehicles for proving the launcher would be developed. The seat of the governing body would be for any forthcoming conference to decide. The staff of the Organisation would be an international body with representatives from each of the Member States, and the development and construction of launchers and test satellites would be carried out by means of contracts placed either by the Organisation itself or by the Governments of Member States. The allocation of contracts and sub-contracts would be determined by the Organisation on the basis of a rational distribution of work among members.

Arrangements would be made for technical information acquired in the course of any project to be freely exchanged by Member States. All participants would be given an opportunity of joining in the scientific, engineering and other work of the Organisation. This would enable them to enjoy the many scientific and commercial benefits that could arise from the development of satellite launchers for peaceful purposes. Dissemination of technical information and knowledge would be helped by the employment of nationals of each Member State in the work being undertaken on behalf of the Organisation in Government Establishments and industrial firms of other countries.

Closest co-operation would be maintained with the projected European Space Research Organisation proposed at the Conference at Meyrin in December, 1960, for collaboration between European countries in carrying out scientific research into space. It is envisaged that E.S.R.O., which would not itself engage in the development and production of launching vehicles, would wish to use those produced by the proposed launcher development organisation.

Technical Background

The Anglo-French proposals envisage the initial three-stage satellite launcher programme as being suitable for launching both research and communication satellites. Quite different requirements are necessary for each purpose and the launcher would be capable of delivering satellites of different weights and end uses into a variety of orbits ranging from low altitude orbits of 100 miles or so when satellite weights could be of the order of 2000 lb, to orbits reaching out to 100,000 miles in the case of small scientific satellites weighing about 100 lb. These widely differing requirements can be achieved through the launching system proposed, only the third propulsion stage needing to be varied to meet the differing aims.

The first stage " Blue Streak " is a 70ft long 10ft diameter rocket weighing about 80 tons. It is propelled by liquid oxygen and kerosene and its two engines are capable of 150,000 lb of thrust each. " Blue Streak " is in an advanced state of development with static test firings already in progress. The French second stage will make use of techniques currently under development in that country. The rocket will be 22ft long, 6ft in diameter and will weigh 8 tons. Its particular job is to increase the speed of the launcher from the 8500 m.p.h. achieved before " Blue Streak " falls away to 14,500 m.p.h., the speed required before the third stage takes over. The final speed necessary will be about 17,000 m.p.h. for a low circular orbit and 20,000 m.p.h. and upwards for higher circular or elliptical orbits. The complete launcher will be radar guided from the ground.

The programme of development proposed at Strasbourg was planned to make full use of the rocket development and test facilities already created in the U.K., France and Australia. In the U.K. there is a " Blue Streak " test site at Hatfield, Herts., the main assembly works are at Stevenage and the Spadeadam Rocket Establishment near Carlisle is equipped for the complete static testing of " Blue Streak " vehicles. In France there are test facilities at Vernon, near Paris, at Toulouse and at Colomb Bechar in North Africa. The facilities built up at the Weapons Research Establisment range at Woomera, Australia, make this range the obvious choice for the testing of the complete multi-stage launcher.

The timing of the programme is a matter for the Organisation ; a successful programme might take about five years from commencement. The Anglo-French proposals estimated about £70,000,000 as the cost of the development for a three-stage launcher programme. The U.K. has agreed to bear 33⅓ per cent of the cost ; the rest would be divided between the participating countries roughly in proportion to national income.

Possible Use of Satellites for Communications*

In studying problems associated with communications satellite systems the following features have been taken as desirable targets :

(i) Continuous twenty-four-hour service should be available for telegraphy and telephony between all ground stations provided in connection with the system.

(ii) World-wide coverage should be provided in association with the existing cable and radio links.

(iii) Provision should be made for the satellites to carry about 1000 telephone channels and one or two television links.

(iv) The system should be capable of carrying the traffic in the minimum number of hops and the bulk of the traffic in one, i.e. by bringing into use only one satellite for the operation.

Much further study will be required before it is known whether these targets can be achieved. In general, however, the number of satellites required in a system would depend on the type of orbit adopted and its height, on whether the satellites are position-controlled in this orbit, and to some extent on the number and location of the ground stations. For example, with position-controlled satellites in an equatorial orbit a system consisting of twelve satellites would need to be put into orbit at a height of between 7000 and 8000 nautical miles, whereas for a system with sixteen satellites an orbital height of between 5000 and 6000 nautical miles might suffice.

The launching of satellites for communications purposes is one of several important uses of a launcher based on the Blue Streak rocket, developed in the way envisaged by the European Launcher Development Organisation.

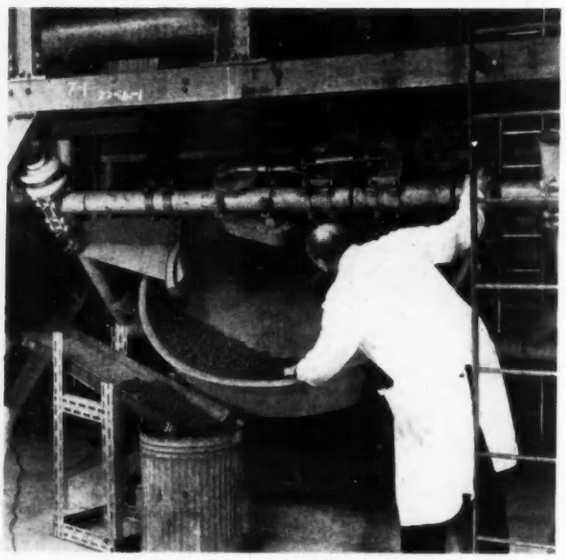
In the White Paper on Post Office Prospects 1961/62 (Cmnd. 1327) reference was made to collaboration between the Post Office and the United States National Aeronautics and Space Administration in tests of satellite communications across the Atlantic. The Post Office is providing an experimental ground radio station on the Lizard, Cornwall, in preparation for experimental tests of satellite communications next year. The tests will cover the transmission of speech, telegraphy, and television across the Atlantic.

Many technical, operational and economic questions will require to be studied before a commercial satellite communications system can be established.

* Communication from the General Post Office.

Building Research

The illustration RIGHT shows the materials laboratory at the Building Research Station at Garston, Herts., which was opened by Sir Harry Melville, Secretary of the D.S.I.R., last Friday. The new building comprises laboratories on the first, second and third floors, each of which consists essentially of a completely open space 200ft by 36ft 8in, subdivided by lightweight partitioning and equipped with services which are flexible, and are based on a 40in grid. Apparatus and building services are comprehensive, and include twelve controlled-temperature rooms. The building was designed by the Ministry of Works, and the main contractor was Wilson Lovatt and Sons, Ltd. ; its total cost was about £260,000.

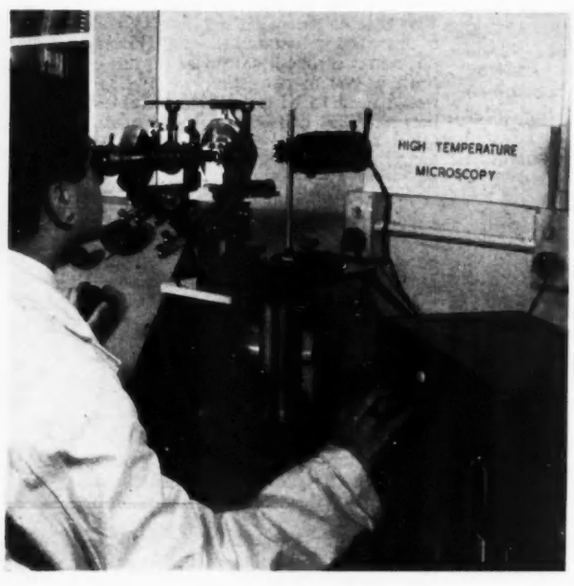


Following the opening last Friday, the Station has been holding open days this week—the first for six years—at which emphasis has been placed on researches on materials. Two examples of current researches are illustrated. LEFT preparation of pellets from pulverised fuel ash, for use as lightweight aggregate (see article on page 68). BELOW LEFT high temperature microscope used to study the growth of crystals in a melt, and BELOW RIGHT lime crystals in such a melt at 2050 deg. Cent. ; the magnification is shown by the wire, which has a diameter of 0·5mm.

The Station has been in the forefront of cement research throughout the world for nearly thirty years, and high-temperature studies are now greatly facilitated by the development at the Station of the high-temperature microscope and its associated high-temperature X-ray camera, which allow direct observation of phase changes up to 2000 deg. Cent. These phase studies are currently helping to determine the extent to which blast furnace slags of differing compositions can be incorporated into concrete mixes as aggregates without introducing undesirable properties into the finished product ; an up-to-date appraisal for this purpose of the slags being produced to-day is thus being aimed at.

The Station's background knowledge of cement chemistry allied with recent research techniques, has allowed the establishment of a successful cement manufacturing industry in Uganda. Limits of proportioning of raw materials were established, and in particular the presence of phosphates in the limestone evaluated.

The effect of additives to cement on their setting properties and strength is also being studied ; in particular investigations are being carried out of the possible effect of calcium chloride, which is added to cement to obtain rapid hardening, on the corrosion of reinforcing steel. Work is being done to explain the properties of set cement, especially shrinkage, in terms of its constitution and physical structure, and also to examine the rates of reaction and reaction of products and their effect on the setting of cements.



SHORTER REPORTS

Institute of Work Study

At a ceremony held in Guildhall, London, recently, the first president of the Institute of Work Study, Mr. R. M. Currie, C.B.E., was invested by Admiral of the Fleet Earl Mountbatten of Burma, K.G., with the Institute's badge of office. The Institute was formally constituted in May 1960 as an integration of a number of societies operating in the work study field. Mr. Currie is a well-known pioneer of work study, and founded the work study department of Imperial Chemical Industries in 1947, when the company, with 110,000 employees, had only thirty engaged on the techniques which now give employment to 1800 full-time specialists. With Mr. Currie's help and guidance work study techniques have been introduced not only into many industrial concerns besides I.C.I., but also into the armed forces, hospitals and agriculture. The work is now international in scope, and the newly-formed European Work Study Federation has also elected Mr. Currie its first president.

London Office for G.K.N. Group

Until 1960 the London address of the Guest, Keen and Nettlefolds Group of Companies was 66, Cannon Street, E.C.4, where it was only possible to house a limited number of the constituent concerns ; other companies in the group had offices in different parts of London. A large new office block, G.K.N. House, is now in use at 22, Kingsway, London, W.C.2, and accommodation has been provided there for about forty companies and group organisations, bringing the whole of the group London office staff under one roof. The building is of seven storeys, on a steel framework with curtain walling and Portland stone end elevations, and has a total floor area of 92,100 square feet. Considerable use has been made of group company products where appropriate ; the internal partitioning and metal office furniture, for example, being by Sankey-Sheldon, while the door fittings are products of Aug. Stenman A/B.

Bus and Coach Speed Limits to be Raised

Last week Mr. Ernest Marples, Minister of Transport, laid before Parliament Regulations which will raise the speed limit for buses and coaches from 30 m.p.h. to 40 m.p.h. outside built-up areas. The new speed limit, which was recommended by the Minister's Departmental Committee on Road Safety, will apply to all passenger vehicles having an unladen weight of more than three tons or adapted to carry more than seven passengers, exclusive of the driver. Smaller vehicles are not subject to any speed limit outside built up areas. The Regulations will require the approval of both Houses of Parliament before the new speed limit can come into operation.

Fuel Oil Instrumentation

We have received details of a number of instruments recently made available for use in the management of oil burning equipment.

The Shandon Scientific Company, Ltd., 6, Cromwell Place, London, S.W.7, has devised a viscometer calibrated in terms of the pre-heat needed to burn the oil efficiently. The viscometer functions by measuring how far a plunger falls through a sample of the fuel in the time taken for a ball to fall a fixed distance through a standard oil, the temperatures of the fuel and the oil in the timer having been equated. The plunger has five sets of calibrations corresponding to desired final viscosities of 75, 110, 155, 200 and 400 seconds Redwood No. 1, and reads directly in the increase of temperature necessary. The instrument will handle oils needing pre-heating by 150 deg. Fah. or more ; it depends on the viscosity index of the fuel being the same as that of all "normal" fuel oils. A chart supplied with the instrument allows the temperature rise necessary to attain seven other viscosities to be computed. It is claimed that determinations can be made in three minutes by unskilled personnel.

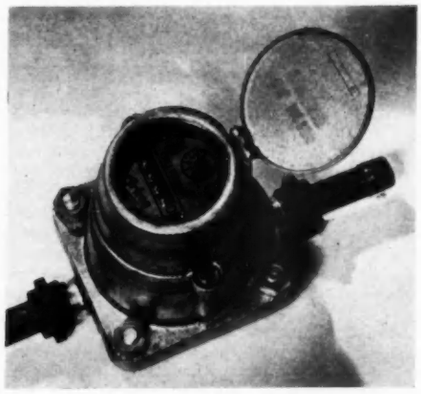
Fuel oil viscometer

[Reply Card No. 1083]

Walker, Crossweller and Co., Ltd., of Cheltenham, is now importing an oil meter which maintains an accuracy of ±1 per cent down to flow rates of 1½ g.p.h. It uses the same mutating piston mechanism as the ½in "Arkon" meter, which functions down to 4 g.p.h., but is specially calibrated.

To function with large flows, this firm has now made available the "Arkon" ball flow indicator in the 1in as well as ½in size ; the white nylon ball appears at an oil flow of ½ g.p.m. (2 cubic feet per minute for gas).

[Reply Card No. 1084]



Made in the United States of America, this fluid meter is calibrated in Imperial gallons ; it records up to 999,999

Elapsed-Time Recorder

A new instrument for recording the time interval during which a piece of equipment has been in operation is being produced by The English Electric Company, Ltd., Strand, London, W.C.2. It can be applied to any equipment which is used intermittently and on which a service log is required for planned maintenance or other reasons. Typical applications include the logging of operational regimes of pumps, heating and ventilating systems and transmitter valves.

Normally the instrument is connected to be switched on and off automatically with the plant or equipment that is being metered. Timing is effected by a self-starting non-reversing synchronous motor driving, through a gear train, a cyclometer register which records up to 9999·9 hours in steps of 0·1 hour. The recorder is suitable for operation on an a.c. supply of 50 or 60 c/s in the voltage ranges of 100V to 125V, 200V to 250V or 400V to 440V.

The meter is available in two forms of case. The first, type H21M, is a 4in square, flush mounting, switchboard pattern case. The motor is mounted internally and two terminals are provided on the base plate to connect the motor to the supply. The meter has a small revolving pointer to indicate that the motor is energised.

The second is a 2½in or 3½in, type S25 or S35, square moulded black plastics case designed primarily for panel mounting. The motor is mounted externally and connection to the supply is made through a pair of flexible leads. It is lubricated with a special grease for operation in extreme temperatures.

[Reply Card No. 1090]

Semiconductor Physics Conference

The Institute of Physics and The Physical Society on behalf of the International Union of Pure and Applied Physics, and the British National Committee for Physics, is arranging an International Conference on The Physics of Semiconductors, which will be held at the University of Exeter from July 16 to 20, 1962. The conference is planned to follow the previous sequence of conferences on the physics of semiconductors, held in Reading, Amsterdam, Garmisch, Rochester and Prague. Further information may be obtained from the Administration Assistant, The Institute of Physics and The Physical Society, 47, Belgrave Square, London, S.W.1.

Gallium Arsenide

It is announced by Johnson Matthey and Co., Ltd., that the firm is now able to offer sample quantities of this intermetallic compound in polycrystalline form. It is also hoped that single-crystal material will be available shortly. Typical properties of polycrystalline gallium arsenide are given below :

Resistivity	0·01–0·2Ω-cm
Hall coefficient	50–250cm³/C
Electron mobility	2000–4000cm²/V s
Carrier concentration... ...	$1{\cdot}30 \times 10^{18}$/cm³

The material is available either as broken ingot or cut slices.

SHORTER REPORTS *(Continued)*

Structural Lightweight Concrete

ONE of the illustrations on page 66 shows the production of lightweight aggregate from pulverised fuel ash at the Building Research Station. Research on this process was one of the subjects to be seen at the open days held at the Station this week, and is explained in the first part of the following note which has been abstracted from the Station's annual report*, and describes generally researches on lightweight concrete.

Lightweight concrete is of importance in building for two main reasons—its use will reduce the dead load in a structure and consequently will economise in foundations and structural design, and it may provide thermal insulation. A range of density from a few pounds per cubic foot up to the density of gravel aggregate concrete (150 lb per cubic foot) is possible, but the lightest concretes require care in use, because of low strength, high water absorption and high shrinkage. The density of concrete may be reduced by using light aggregates, by creating a cellular structure (aerated concrete), or by omitting fine aggregate (no-fines concrete).

Hitherto lightweight concrete has mostly been used in the form of blocks or of roof screeds cast *in situ*, but there is now a rapidly increasing interest in structural lightweight concrete, i.e. reinforced concrete of medium density, in fairly large units.

The Station's studies are concerned both with the production of lightweight concrete and also with the properties and design of reinforced lightweight concrete. The work began in the early days of the Station's existence with the study of furnace clinker and expanded slate, and this was followed about 1935 by an important contribution to the development of foamed blastfurnace slag. Immediately after the war some work was done on aerated concrete, and this has recently been taken up again because of a sudden and rapidly expanding interest shown by the building industry in this type of concrete. During the past few years research has been concentrated on the development of sintered pulverised-fuel ash aggregate.

The general adoption since the war by the Central Electricity Generating Board of the use of pulverised coal for steam-raising has resulted in a large production of pulverised-fuel ash, now exceeding 5,000,000 tons per annum; simultaneously the output of furnace clinker suitable for use in concrete has declined. The Station was asked to assist in solving the problem of disposal of this large quantity by suggesting uses for it in building and civil engineering. Among other proposals studied was the conversion of the fine ash into a sintered product, suitable for use as lightweight aggregate.

Two processes were fully studied by pilot-scale production and laboratory investigations. In both, the ash is first rolled into nodules by the addition of water in a revolving pan and subsequently roasted at about 1200 deg. cent., using as fuel the small amount of unburnt coal remaining in the ash. According to the level of unburnt fuel in the ash either a shaft kiln or a sinter strand was used for ignition. The latter process proved to be the more easily controlled. Sintered p.f.a. is a high grade aggregate, giving concrete with a good strength-to-density ratio, and a drying shrinkage below that usually met with in lightweight concrete.

Two commercial plants have been erected by private firms to produce sintered pulverised-fuel ash, and pilot-scale work has correspondingly been curtailed. [Further research into the cementitious properties of p.f.a. is now being done, and the C.E.G.B. is lending its support].

Lightweight aggregate can also be made by sintering suitable clays, shales or slates, and assistance has been given to firms in determining whether deposits under their control can be processed into aggregate.

Research on reinforced lightweight concrete was initiated at the Station in 1957, and has been assisted by manufacturers of lightweight aggregates. Reinforced concrete made with lightweight aggregates is now being used for the construction of important buildings. The main reason for this development is the economic advantage to be gained for structures of large span or weight by using material that has high thermal insulating capacity, is lighter than ordinary concrete and yet has comparable strength. When lightweight concrete is used for roofing an additional thermal insulation screed becomes unnecessary. The use of precast lightweight aggregate or aerated concrete members also makes it possible to speed up construction on the site.

The rules governing the design and use of reinforced lightweight concrete are essentially the same as those which apply to ordinary, dense-aggregate concrete. There are, however, some important differences due to the different physical characteristics of this material, and these must be taken into account. The effect of these different characteristics on structural design and durability has formed the subject of the research programme, which has now progressed sufficiently for some conclusions to be drawn. For the same compressive strength the bond strength of lightweight concrete was found to be considerably lower than the bond strength of dense-aggregate concrete. Owing to its lower modulus of elasticity the deflection under load of lightweight concrete flexural members is higher than that of dense concrete members, and because of this and the lower bond strength, the cracking characteristics are likely to be somewhat more unfavourable, i.e. the cracks will tend to be wider and more widely spaced. Shrinkage of compacted lightweight concrete is generally higher than that of dense concrete, although this effect is partly compensated for by higher creep in the former. The durability of lightweight concrete depends more on the quality of the concrete used, i.e. its cement content, workability and compaction, than on the type of aggregate used. Resistance against corrosion of the reinforcement is likely to be influenced by the rate at which carbonation of the cement proceeds inwards from the surface of the concrete, and this rate is somewhat greater in lightweight concretes than in dense concrete.

The ultimate aim of the work on reinforced lightweight concrete is to provide a foundation upon which future Codes of Practice can be based. In the meantime the Station gives information and advice to local authorities, to help in dealing with applications for waivers from byelaws and in formulating policy on the structural use of lightweight concrete in the building and civil engineering industries.

A comparable material which has lately been introduced in this country is reinforced aerated or " gas " concrete. Work at the Station on this material has been mainly on problems of bond strength, durability and creep. In view of the low resistance against corrosion of the reinforcement it has been found necessary to protect the embedded steel and various types of protection are being examined.

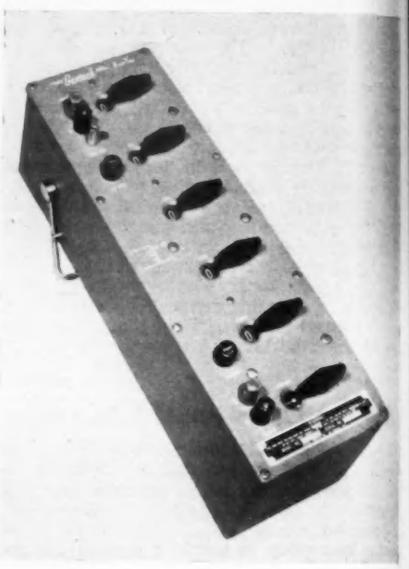
* Building Research 1960. H.M. Stationery Office. Price 7s.

Ratio Transformers

UNDER a sales agreement concluded recently with Gertsch Products Inc., sole marketing and manufacturing rights of Gertsch electronic instruments in the United Kingdom are now held by Wayne Kerr Laboratories, Ltd., 44, Coombe Road New Malden, Surrey. Among these is the Wayne Kerr–Gertsch ratio transformer illustrated, which has applications as the standard ratio arm of a bridge, or as an a.c. potentiometer for checking resolvers, servos, transformers and computers. Two of units, RT4 and RT5, operate from 30 to 1000 and 50 to 10,000 c/s respectively. Over the lower frequency range, ratio accuracies of 0·001 per cent are claimed, and 0·01 per cent over the higher range.

Ratios are selected by operating five decade switches and a single-revolution potentiometer. This arrangement provides continuous resolution and readout of better than six significant figures, each ratio value being shown as a direct decimal reading.

Both units have a terminal linearity of 0·00[illegible] per cent and a very small phase angle under loaded conditions—the actual size of the angle depending on the frequency and ratio setting.



Ratio transformer providing continuous resolution and decimal readout by means of decade switches and a potentiometer

Effective series impedance of the RT4 is 4 ohms and its input inductance 500H ; comparable figures for the RT5 are 3 ohms and 150H. Normal temperature range for both transformers is from −15 deg. to +80 deg. Cent. Each unit is available either in a cast aluminium case or rack mounted with an aluminium dust cover.

[Reply Card No. 1086]

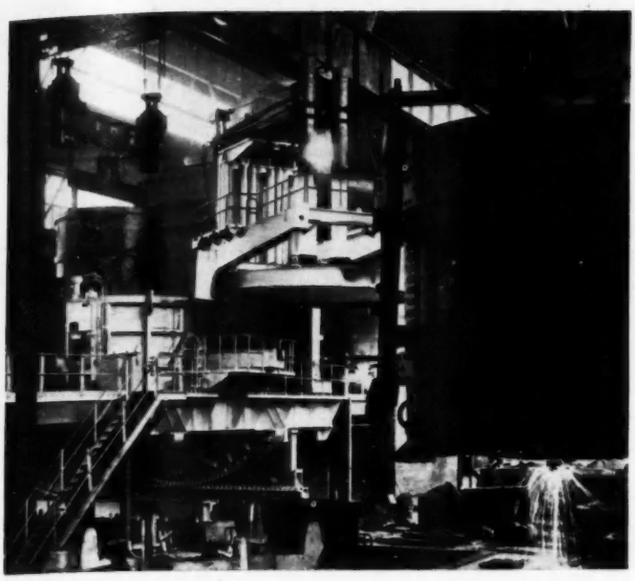
Weight Trip Amplifier for Cranes

INDICATION of the approach or attainment of maximum safe load on a crane is provided for the operator by a load cell, weight trip amplifier, and indicator equipment introduced by Ekco Electronics, Ltd., Southend-on-Sea, Essex. The fully transistorised amplifier uses a 12V battery supply. Two main systems are available. The first provides an amber lamp signal at the preset safe load and two further lamp signals at a predetermined percentage deviation below and above the safe load respectively. The second system provides a red signal lamp indication when the safe load limit is reached, in addition to continuous meter indication of actual safe load percentage. Provision is made in both systems for operation of an audible alarm.

This type N684 equipment has a safe load alarm accuracy of ±0·5 per cent and a deviation alarm accuracy of ±2½ per cent of setting, over a temperature range of −10 deg. to +40 deg. Cent. The amplifier circuits are designed to provide a red alarm in the event of any part of the internal circuit failing, while a green lamp indicates that the battery supply is connected.

The complete equipment consists of three main units : the load cell, main amplifier, and indicator unit. The load cell comprises a bonded pressure-sensitive resistor element and is installed at a suitable strain point on the crane. The main amplifier is housed in a strong, weather-proof case and incorporates the trip set controls, while the weatherproof indicator unit is positioned in the most convenient position for the crane operator.

[Reply Card No. 1085]



80-ton electric arc furnace at River Don works

Developments at English Steel

AT the Tinsley Park site, Sheffield, recently, the construction work for the new steel works of the English Steel Corporation, Ltd., was formally inaugurated by the chairman of the company, Viscount Knollys. Already nearly 3,000,000 tons of earth have been moved on the 500 acre site (derelict mine workings), and construction of foundations and buildings is now in progress. The works, when complete, will house two 100-ton electric arc furnaces, a 42in blooming mill, two 32in billet mills, and bar mills, for the production of alloy and special carbon steels. This plant will enable E.S.C. to increase its production to nearly 1,000,000 tons of special steels a year.

On the same day, Lord Knollys also set to work new plant at one of the existing E.S.C. works, River Don, Sheffield. This equipment consists of an 80-ton electric arc melting furnace, and a vacuum casting chamber. The furnace, made by Birlec-Efco (Melting), Ltd., has a shell diameter of 21ft, and, with an electrical rating of 20MVA, is capable of melting an 80-ton charge in less than three hours. A new feature in this furnace is that the shell is split horizontally just above the slag line, the upper half being detachable.

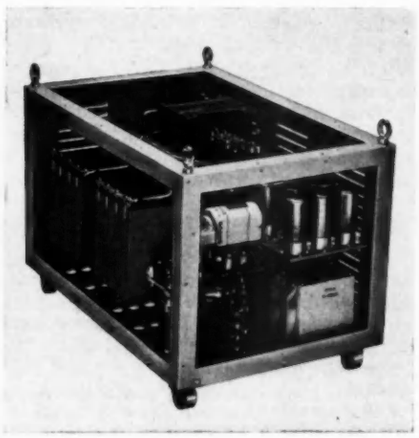
To replace the side wall brickwork, the entire upper half is lifted off in a manner similar to that used for removing an arc furnace roof and a spare upper half, already bricked, is lowered into position.

Adjacent to the new arc furnace is the vacuum casting vessel. This has been built largely by E.S.C. to Bochumer Verein design. This vessel will be fed by the new furnace, and, if other melting plant already installed is also brought into use, it will be possible to cast ingots in vacuum up to 180 tons in weight. A new overhead travelling crane, by Clyde Crane and Booth, Ltd., has been installed to serve the arc furnace and vacuum casting equipment. This crane has a span of 60ft, and runs on a gantry 59ft above the shop floor. It will lift 200 tons on the main hoist and 50 tons on the auxiliary.

Vacuum casting vessel with ladle in casting position

Stabilised Power Supply

Two high-current stabilised d.c. power supply units are announced by Claude Lyons, Ltd., Valley Works, Hoddesdon, Herts. From a 240V a.c. input, the PSS-32/50-A unit (illustrated with covers removed) provides 50A d.c. at 24 to 32V The second unit, PSS-32/50-B, has two separate switched ranges of 20-28V and 24-32V, at the same current output. The operating principle is that the a.c. supply to the rectifying and smoothing circuits is adjusted automatically by a "Variac" variable transformer, controlled by a high-speed transistorised servo-mechanism so as to correct for any error in the output voltage. For this purpose the mains input is applied to a step-down transformer and also to the servo-controlled "Variac". The variable output of the "Variac" is taken to the primary winding of a buck-and-boost transformer, the secondary of which is in series with the input from the mains transformer secondary to the rectifier.



High-current d.c. power supply unit with servo-motor control of "Variac" transformer

A proportion of the stabilised output voltage is fed to the servo-amplifier, where it is compared with a reference voltage derived from a semiconductor diode bridge rectifier and two Zener diodes. Any difference is amplified and applied to transistors acting as amplifier and switches controlling the servo-motor armature supply. When the stabilised output voltage falls, the amplifier causes the servo-motor to drive the "Variac" brushgear in such a direction that an in-phase voltage builds up in the secondary of the buck-and-boost transformer, and this is additive tive to the voltage supplied to the retifier by the mains transformer. When the stabilised output voltage rises, the servo-motor is made to drive in the reverse direction.

In the accompanying illustration the servo-motor and "Variac" are seen in the left foreground. The servo-amplifier is on the base of the chassis to the right, below a group of capacitors. If variations due to supply voltage on load current exceed the correction range of the unit the "Variac" brushgear operates a limit switch at one or the other end of its travel. Operation of a limit switch interrupts the motor armature supply so that protection is given against overheating of the motor or damage to the motor. When either limit switch is open, there is a parallel path to the servo-motor armature through the other switch, but this includes a diode which conducts only when the current from the servo-amplifier is in the direction necessary to drive the motor away from the limit.

[Reply Card No. 1088]

Long-Range Photoelectric Equipment

A LONG-RANGE photoelectric equipment (Series MPU.2) has been designed by Lancashire Dynamo Electronic Products, Ltd,. Rugeley, Staffs., for use where the direct line of sight distance between the projector and receiver units may be as much as 1500 yards (1370m). Modulation of the light beam by a scanning disc driven by a gramophone type motor and the design of the receiver so that it responds only to the appropriately modulated signal prevent spurious operation by extraneous light. Semiconductors are used exclusively in the receiver unit, and the system is arranged to fail to safety if tampered with. Optical and mechanical means are fitted on the standard equipment as illustrated for initial alignment of the two units. Apart from applications as an intruder alarm, the Series MPU.2 equipment can be used for navigational warnings, (for example, to operate a fog warning) and also for on/off signalling where the expense of laying cables would be prohibitive. Industrial applications occur where normal photoelectric units are inoperable due to high ambient light levels.

[Reply Card No. 1087]

Projector of long-range photoelectric warning system using modulated light beam

INDUSTRIAL NEWS

Sale of Barrow Steel Works

The United Steel Companies, Ltd. has purchased Barrow Steel Works, Ltd., from the Iron and Steel Holding and Realisation Agency for the sum of £2,200,000. United Steel has managed this works since 1943 for a token remuneration. As a conventional steel-producing unit, the works has not been economic throughout this period. The re-rolling mills are not in themselves uneconomic, but their steel requirements are insufficient to support their own steelmaking furnaces, while the location of Barrow prevents the regular acquisition of billets from other sources of supply.

Continuous casting was considered to be the most promising form of small-scale billet production, based on local scrap supplies, and in the hope of converting the works into a profitable undertaking, a pilot continuous casting unit was installed in 1952. Since 1954, United Steel has borne the operating cost of the subsequent experimental work in view of its own interest in continuous casting developments. The process is now working successfully, and two full-scale twin-strand continuous casting machines together with a 20-ton electric arc furnace are being installed. This plant is expected to come into production in the near future, and should provide billets at a cost which will enable the Barrow re-rolling mills to operate at a profit and so justify their continued existence. The scheme has been given the code name BARCON (**B**arrow Steel Works **AR**c Furnace **CON**tinuous Casting).

Employment

The Ministry of Labour has announced that during May, 1961, the number of people in civil employment in Great Britain is estimated to have increased by 41,000 to 23,809,000. There was little change in employment in the manufacturing industries as a whole. In the engineering and electrical goods group the number employed rose by 3000, the Ministry says; in the metal manufacturing industries it dropped by 1000, and in the metal goods group there was no change. In the motor vehicle industry the number of people employed rose by 2000 and in shipbuilding and marine engineering there was no change. There was an increase of 7000 in the number employed in the construction industries whilst in mining and quarrying, the total dropped by 4000.

In the week ended May 27, 1961, the Ministry states, the estimated number of operatives working overtime in establishments with eleven or more employees in manufacturing industries, excluding shipbuilding and ship-repairing, was 1,823,000, each working seven hours overtime on average. In the same week, the estimated number of employees on short-time in these establishments was 36,000, each losing thirteen hours on average.

Quality and Reliability

Following a meeting of twenty-two organisations representative of British industry at all levels, including the Trades Union Congress and Service and Government Departments, held in London last week, it was announced that Britain is to have a National Council for Quality and Reliability. Sir Charles Norris, director of the British Productivity Council, which has been campaigning for quality control through its quality control committee and courses since 1956, presided at the meeting. The aims of the national organisation will be to supplement the activities of existing organisations (it is not intended that these should be absorbed or replaced); to act as a central source of information; to advise on quality control and reliability training courses, and organise conferences.

The British Productivity Council is to provide secretarial services. Chairman of the National Council is Mr. Frank Nixon, consulting engineer (quality), Rolls-Royce, Ltd. and president of the European Organisation for Quality Control.

Transport Costs in Northern Ireland

The Northern Ireland Development Council has announced the results of its inquiry into transport costs as a factor affecting industry in Ulster. The inquiry, which had been undertaken to obtain information for the guidance of any firm considering the establishment of a new firm in Northern Ireland, covered fifteen different types of industry. Results showed that in all but one transport of finished products from Northern Ireland did not exceed 2·8 per cent of the sales value. In ten of the industries transport costs were less than 1·5 per cent of sales value. Costs of inward transport of raw materials were in all cases less than 2 per cent, the Council says, and in nine industries were under 1 per cent of sales value.

Light engineering was one of the industries covered by the inquiry and in this the transport costs of finished products was 0·6 per cent of the sales value, whilst the cost of inward transport of raw materials was 1·9 per cent.

The Council points out that the figures represent total costs of transport and not an extra cost resulting from manufacturing in Northern Ireland. It is evident from the inquiry, the Council adds, that for many industries transport costs form so small a percentage of the costs of production that the extra costs of a Northern Ireland location have no great significance, and are more than likely to be offset by the other savings in an area with a labour surplus.

Imports of Ships

The Shipbuilding Conference has issued a statement in which it examines the validity of the phrase "Britain has become a net importer of ships" which has found frequent expression in many quarters. The "crude" net import figures for 1959 and 1960 are stated to be misleading and it is pointed out that proper emphasis must be given to the preponderance of oil tanker building following the spate of orders placed during the Suez crisis by the big oil companies. Since it was impossible to obtain sufficient berths in this country it was necessary to place orders abroad. Statistics show that from 1955 there has been a decline in tonnage built for export and an increase in tonnage imported with the 1959 returns showing a change-over to a "net import" of 334,000 gross tons, the figures for 1960 being of a similar order. An examination of the 1959 returns, the Conference states, shows that the ships launched abroad for United Kingdom registration included 386,000 gross tons of oil tankers, or 86 per cent of the total, 75 per cent of which was for the international oil companies such as Shell, BP, Esso and Caltex, and 9 per cent for the independent oil companies, and were contracted for in 1955 during a period of intensive ordering. The remainder of the total of British ships ordered abroad amounted to about 63,000 gross tons, or 14 per cent, and represented eleven cargo ships and thirteen coasters, &c. The corresponding figures for 1960 were 319,000 gross tons launched abroad for British owners of which oil tankers represented 69 per cent. More than half of the oil tanker tonnage was to the "independents" account and reflected the later ordering of the latter companies. Of the balance of imported tonnage, amounting to 146,000 gross tons, some 72 per cent was to the account of London Greek owners who are international operators. The statement concludes by mentioning that the imported tonnage for the years 1957 and 1958 was considerably lower at 157,628 and 285,381 gross tons respectively, the respective totals including 75 and 71 per cent of oil tankers.

Exports of Electrical and Allied Engineering Goods

The British Electrical and Allied Manufacturers' Association states that exports of electrical products and associated equipment during the first five months of 1961 were 8 per cent higher than in the period January to May, 1960. The total value of these exports amounted to £138 million, compared with £127,900,000 for the corresponding period of the previous year. The largest advances, the Association says, were made by the radio and telecommunications group and domestic appliance group. The former increased from £27,500,000 to £32,400,000, radio communication and navigational aid equipment accounting for £9,000,000 of this, whilst sales of domestic electrical appliances advanced by over £2,000,000 to £15,000,000 for the five months. Exports of electrical and allied machinery remained practically the same at £37,000,000, but exports of cables and wires fell slightly to £10,000,000 for the period.

Commonwealth countries continued to be the chief destinations of electrical exports, sales to Australia, New Zealand and South Africa showing substantial improvement on the corresponding period of last year. More notable, however, the Association points out, was the increased trade to the Common Market. Exports to the "Six" rose by 50 per cent over the five months, while deliveries to Britain's partners in E.F.T.A. rose by over 13 per cent. On the other hand, however, sales to both the United States and Canada are down on last year so far.

Electrical imports into the United Kingdom are rising more slowly. The total of £28,900,000 for January to May, 1961 compares with £27,900,000 for the corresponding period last year, a rise of 4 per cent. Radio and electronic equipment accounted for about 28 per cent of the imports.

PERSONAL AND BUSINESS

Appointments

MR. S. R. BADLEY has been appointed a director of Extrudex, Ltd.

MR. JUSTIN H. SCOTT, has been appointed to the board of Laurence, Scott and Electromotors, Ltd.

HEYES AND CO., Ltd., announces the election of Alderman W. H. Bellis as chairman of the board.

MR. A. D. THOMSON, has been appointed deputy managing director of Edwin Danks and Co. (Oldbury), Ltd.

MR. ERNEST BEALING has been appointed chairman of Sandvik Steel Band Conveyors, Ltd., in succession to the late Mr. J. F. Sjogren.

MR. A. K. SIMCOX, MR. J. S. HUGHES and MR. H. N. FENN have been appointed to the board of directors of Midland Silicones, Ltd.

MR. JOHN T. MCCARLEY, director of manufacturing—international, has been appointed managing director of the British division of the Yale and Towne Manufacturing Company. He succeeds Mr. John O. Sewell.

THE INSTITUTE OF PHYSICS and THE PHYSICAL SOCIETY announce that Sir John Cockcroft has been elected President, and Dr. V. E. Cosslett, Professor R. W. Ditchburn, Dr. W. H. Taylor and Dr. J. Topping, vice-presidents.

MR. PERCY ALLAWAY has been appointed managing director of E.M.I. Electronics, Ltd., in succession to Mr. Clifford Metcalfe, who relinquished the post at his own request but remains a full-time director of Electric and Musical Industries, Ltd.

THE GENERAL ELECTRIC COMPANY, Ltd., states that Mr. J. F. Prince, manager of the export sales department at the Witton Works, has retired after forty-two years' service. He has been succeeded by Mr. K. D. Starr, A.M.I.E.E., A.M.I.Mech.E.

MR. HENRY FOXWELL SHERBORNE, managing director of Yorkshire Imperial Metals, Ltd., has been appointed President of the British Non-Ferrous Metals Federation in succession to Mr. W. W. Dolton, managing director of the Delta Group of Companies.

MR. J. A. V. WATSON will be appointed assistant managing director of Castrol Industrial, Ltd., upon the retirement of Mr. W. F. List on January 1, 1962. Mr. Watson's appointment as an assistant managing director of the parent company, Castrol, Ltd., to take effect on the same date, has already been announced.

DORMAN LONG AND CO., Ltd., announces that Mr. G. E. Chicken, commercial manager of Dorman Long (Steel), Ltd., and Mr. C. Hipwell, general manager of Redpath Brown and Co., Ltd., have retired from their executive positions on the board of Dorman Long and Co., Ltd. Mr. Chicken will continue as a non-executive director and Mr. Hipwell will remain a director of Redpath Brown and Co., Ltd. New executive directors appointed are Mr. George Foster, general manager, production, and Mr. Ernest N. Highton, general sales manager of Dorman Long (Steel), Ltd. Mr. J. D. Bolckow, who succeeds Mr. Hipwell as general manager of Redpath Brown and Co., Ltd., has been appointed a special director of Dorman Long.

THE CENTRAL ELECTRICITY GENERATING BOARD states that following the Regional reorganisation the following appointments of deputy and assistant regional directors have been made : South Eastern Region, Mr. L. W. Stretton, M.I.E.E., becomes deputy regional director ; Mr. F. W. Skelcher, M.I.E.E., M.I.Mech.E., becomes assistant regional director, North Thames Division ; Mr. W. H. Dunkley, M.I.E.E., M.I.Mech.E., becomes assistant regional director, South Thames Division. South Western Region, Mr. R. H. Coates, M.I.C.E., M.I.E.E., M.I.Mech.E., becomes deputy regional director ; Mr. E. McCabe, M.I.E.E., M.I.Mech.E., becomes assistant regional director, Southern Division ; Mr. H. S. Davidson, M.I.E.E., becomes assistant regional director, Western Division ; Mr. W. Wilde, M.I.E.E., M.I.Mech.E., becomes assistant regional director, South Wales Division. Midlands Region, Mr. J. B. Jackson, M.I.E.E., M.I.Mech.E., becomes deputy regional director ; Mr. W. F. Cusworth, A.M.I.E.E., becomes assistant regional director, West Midlands Division ; Mr. O. S. Woods, M.I.E.E., M.I.Mech.E., becomes assistant regional director, East Midlands Division. North Eastern Region, Mr. C. G. Richards, A.M.I.Mech.E., A.M.I.E.E., becomes deputy regional director ; Mr. E. Forth, M.I.Mech.E., becomes assistant regional director, Northern Division ; Mr. G. B. Jackson, M.I.E.E., becomes assistant regional director, Yorkshire Division. North Western Region, Mr. J. L. Ashworth, A.M.I.E.E., A.M.I.Mech.E., becomes deputy regional director ; Mr. D. F. Grant, A.M.I.E.E., becomes assistant regional director.

Business Announcements

RESEARCH ENGINEERS, Ltd., has moved to Orsman Road, Shoreditch, London, N.1 (telephone, Shoreditch 7811/5).

C. F. CASELLA AND CO., Ltd., has moved its offices and works to Regent House, Britannia Walk, London, N.1 (telephone, Clerkenwell 8581, 6 lines).

THE ASSOCIATED ETHYL COMPANY, Ltd., 20, Berkeley Square, London, W.1, has changed its name to the Associated Octel Company, Ltd.

FENTER MACHINE TOOLS, Ltd., 184, Aston Road, Birmingham, 6, has been appointed sole agent in the United Kingdom for Eumuco forging machines.

MR. ARCHIE PRESSLEY, manager of the machine tool section of the machinery department of Thos. W. Ward, Ltd., has retired after over fifty-one years' service with the company.

JOHN MILES AND PARTNERS (LONDON), Ltd., 76, Cannon Street, London, E.C.4, states that as from July 22 its address will be Moor House, London Wall, London, E.C.2 (telephone, Metropolitan 0471).

SOUTH WESTERN MARINE FACTOR, Ltd., Poole, announces that as from September 1, 1961, it has been appointed the sole concessionaire in the United Kingdom and Republic of Ireland for the Mercury outboard-motors manufactured by the Kiehkaefer Corporation of Wisconsin, U.S.A.

EPSYLON INDUSTRIES, Ltd., FELTHAM and COMPAGNIE DES COMPTEURS, Paris, have entered into an agreement to manufacture and market in their respective territories certain of each others' magnetic recording products. To start with Epsylon, a member of the Stone-Platt Group, will market the PEN.3 digital tape deck and Compagnie des Compteurs will handle Epsylon's newly developed general purpose tape deck type MR.300.

DU PONT COMPANY (UNITED KINGDOM), Ltd., 76, Jermyn Street, London, S.W.1, states that a plant for the manufacture of isocyanates, a basic raw material used in the production of urethane foams is to be built on its plant site at Maydown, near Londonderry, Northern Ireland. This new facility will supply " Hylene " organic isocyanates, used in making both rigid and flexible urethane foams for markets in the United Kingdom and for export to other countries in the Free Trade Area.

FLEXIBOX, Ltd., Nash Road, Trafford Park, Manchester, 17, has announced the formation of two new subsidiary companies : the new Italian company —Flexibox S.p.A.—commenced operations on July 1. It was formed jointly by Flexibox, Ltd., and its Italian agents—Tecnologie Industriali—and operates from Via Mauro Macchi 27, Milan. In Australia the new subsidiary is known as Flexibox Pty., Ltd., and is owned jointly by Flexibox, Ltd., and Harland Engineering (Australia) Pty., Ltd., Victoria.

MASSEY-FERGUSON (UNITED KINGDOM), Ltd., Coventry, and the BUTLER MANUFACTURING COMPANY, of Kansas City, have announced that a new company, Massey-Ferguson-Butler, Ltd., is being formed with an equal shareholding, to market the range of Butler designed grain handling, drying and storage facilities, bulk feed bins, and farm buildings in the United Kingdom and overseas. Some components will be imported from Butler's Canadian manufacturing plant as an introductory measure, but Massey-Ferguson is formulating plans to manufacture Butler equipment in the United Kingdom for the British domestic market and also for export. Mr. Gilbert Hunt, managing director of Massey-Ferguson (United Kingdom), Ltd., is chairman of the board of the new company.

S. SMITH AND SONS (ENGLAND), Ltd., states that with effect from midnight on August 6, 1961, its subsidiary companies, Smiths Aircraft Instruments, Ltd., Kelvin and Hughes, Ltd., Waymouth Gauges and Instruments, Ltd., and Kelvin and Hughes (Aviation), Ltd., will cease to trade under these names, and their activities will be co-ordinated by a new division of the parent company, to be known as Smiths Aviation Division. This division, with administrative, executive and technical sales headquarters at Kelvin House, Wembley Park Drive, Wembley, Middlesex, will come formally into being as from August 6. The undertakings of the above-mentioned subsidiary companies will be transferred to S. Smith and Sons (England), Ltd. The managing board of the Division is as follows : Mr. R. Gordon-Smith, chairman ; Mr. L. A. Morgan, director and general manager ; Mr. A. M. A. Majendie, director and deputy general manager ; Mr. L. C. Harman, administration director ; Mr. K. Fearnside, technical director. Mr. D. G. Johnson has been appointed as chief technical sales executive and is now responsible for sales and contract matters. In relinquishing his previous appointment as contracts manager, he has been succeeded by Mr. R. E. Leete.

Contracts

WILLIAM BAIN AND CO., of Coatbridge and London, has secured orders for the bridge steelwork in contracts numbers 3 and 5 of the Forth Road Bridge. The orders are valued at approximately £54,000, and involve the supply of nearly 800 tons of high tensile steel castellated bridge beams, some of which are 4ft 6in deep and 82ft long. The consulting engineers are Messrs. Mott, Hay and Anderson and the main contractors for contract No. 3, the southern approaches, are A. M. Carmichael, Ltd., and for contract No. 5, the northern approaches, Whatlings, Ltd.

AUTOMATIC CONTROL ENGINEERING Ltd., has been awarded the contract for the design, supply and installation of the instrumentation of the O.E.E.C. High-Temperature Gas-Cooled reactor, known as the " Dragon " project. The contract provides for the purchase of all instruments and associated equipment by competitive tendering among firms in the territories of the signatories to the O.E.E.C. High Temperature Reactor Agreement. The instrumentation will include a data logging system for recording approximately 900 variables and providing for preset alarm levels and digital displays. The contract is due to be completed by December, 1962.

Miscellaneous

INSTITUTION OF ELECTRICAL ENGINEERS.—The president of the Institution of Electrical Engineers for the session 1961–62 will be Mr. G. S. C. Lucas. Other vacancies on the I.E.E. council will be filled as follows : vice presidents, Mr. A. H. Mumford and Mr. R. L. Smith Rose ; honorary treasurer, Mr. C. E. Strong ; ordinary members of council, Sir Robert Cockburn, Dr. J. S. Petrie, Professor C. W. Oatley, Mr. H. West, (Members), Dr. J. Brown and Mr. P. L. Taylore (Associate Members) ; companion The Rt. Hon. The Viscount Falmouth. The chairmen of the section committees will be as follows : Electronics and Communications Section, Mr. R. J. Halsey ; Measurements and Control Section, Mr. W. S. Elliott ; Supply Section, Dr. J. S. Forrest ; Utilization Section, Dr. H. G. Taylor.

Awards

THE administrators of the Sir George Beilby Memorial Fund, representing the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals, have decided to make awards from the Fund in 1961—each consisting of the newly instituted gold medal with a prize of 100 guineas—to Dr. Constantin Edeleanu in recognition of his work on the corrosion of metals and alloys, with special reference to the development of the potentiostat technique and its applications to the study of practical problems, and on the characteristics of corrosion reactions in fused salts, and to Professor Jack Nutting in recognition of his work in physical metallurgy, especially in the application of the electron microscope to the study of the relationship between microstructure and mechanical properties of metals and alloys and to the investigation of phase changes and dislocation interactions.

THE COUNCIL OF THE INSTITUTION OF ELECTRICAL ENGINEERS have made awards of premiums for papers read or accepted for publication in 1960. These awards include the following : Kelvin premium, Professor F. C. Williams, Dr. E. R. Laithwaite, J. F. Eastham, L. S. Piggott and W. Farrer ; John Hopkinson premium, Mr. F. Kift ; Ambrose Fleming premium, R. F. Cleaver, P. Sothcott and Group Capt. F. J. Robinson ; Mather premium, B. J. Davies, R. C. Robbins, C. Wallis and R. W. Wilde ; Sebastian de Ferranti premium, L. Gosland, R. G. Parr and G. S. Buckingham ; John Snell premium, E. C. Rogers and D. J. Skipper ; Crompton premium, W. R. Stevens and H. M. Ferguson ; Swan premium, K. F. Bacon ; Frank Gill premium, Dr. R. L. Grimsdale and P. H. Sinclare ; Heaviside premium, R. G. Medhurst ; Coopers Hill War Memorial Prize and Medal, 1961, Dr. A. E. Karbowiak for his paper on " Microwave Aspects of Waveguides for Long Distance Transmission."

Death

WE regret to record the death of Mr. William Yorath Lewis, M.I.Mech.E., A.M.I.E.E., A.M.I.C.E., which occurred on July 7, at the age of 87. Mr. Lewis was interested in the problem of continuous transit in large cities, and invented the " never-stop " railway system, which was installed at the Empire Exhibition, Wembley, in 1924.

CONTINENTAL AFFAIRS

by Our Continental Editor

Continental Airport Developments

No. II—(*Concluded from page* 34, *July* 7)

Increasing passenger traffic and the use of larger and heavier aircraft, notably jet airliners, is forcing the pace in many countries as regards improvements to passenger buildings, movement control, and runway installations. In our issue for November 13, 1959, *pages* 613-617, *we dealt with the expansion of the Paris airports of Orly and Le Bourget. On the following pages will be found a brief account of similar work and projects concerning the international airport at Stockholm–Arlanda, and that of the Austrian capital at Schwechat.*

PASSENGERS at Vienna-Schwechat board the buses or are set down at one of the gates corresponding to aircraft positions of the nearest line of docks. From the gates covered corridors connect with the terminal building, the routes being signposted by remote-controlled indicators showing (on the departure side) the next seven flights together with any last-minute alterations in the times. The passenger building is on two levels of which substantially only one is being used at present for passengers, providing a capacity of 900 persons per hour. Luggage registration which is still largely carried out at city airline offices is to be concentrated at the airport terminal, while a central bus station in the city will form the beginnings of a city air terminal. At the departure of an aircraft carrying some 100 passengers, in order to achieve the greatest possible check-in speed, four to five desks with weighing machines must be available simultaneously. The different airlines therefore have no desks of their own but share the available facilities in turn.

The passenger terminal represents a highly successful example of modern architecture. The basic structure is in reinforced concrete, with longitudinal prestressing of the wings which enables expansion joints to be spaced 100m apart instead of the usual 30m to 35m.

The main hall, an area of 60m by 80m, is covered tent-fashion by a 6cm thick suspended concrete skin. Special compression members support the very large thrust forces which arise. Much care has been taken with the casting of the *in situ* concrete. White concrete was used, and all shuttering was carefully finished to cabinet-makers' standards. Similar prefabricated grooved slabs were used to cover the facades and parapets. The roof was covered in plastic, glued to an insulating underlayer of cork. The glazed surfaces are equipped with remote-controlled blinds, the lateral windows, because of the curvature of the ceiling line, being fitted with vertical Venetian blinds. Glass doors in the departure and arrival section are operated automatically by underfloor switches.

Specially high demands were made as regards the quality of sound reproduction of the loud-speaker system, in order to get a satisfactory rendering of many different languages. An impression of personally addressing the individual was obtained by installing a larger number of low-power speakers, and cladding a large proportion of the wall and ceiling area with sound-absorbing panels.

The windows are double-glazed with two panes of different thickness spaced 2cm to 3cm apart and sealed hermetically in steel frames. The glazed walls employ to a great extent hollow rectangular steel sections. The sound-absorbing panels are perforated plaster filled with glass wool, the outside forming at the same time part of the scheme of decoration. The walls are decorated with friezes, inlaid with coloured marble, or painted. Various themes have been used in keeping with the different sections of the building, thus, the arrival hall has Viennese motifs, the departure hall motifs alluding to travel and distant countries, the transit hall Austrian scenery, and the wall frescoes on the stairs, motifs symbolising the air and flight. Abstract design on the first floor are inspired by the Caucasian folk-tale "The Stone Flower," A wide variety of decorative techniques includes sculptured and painted sandstone panels, etched glass, mosaics, hand-woven tapestry, and sculpture.

Access Roads.—From the federal road Vienna–Fischamend–Hainburg the access road to the airport branches off at a point at which the width was increased to 14m. At the same place is the exit which later on will be taken underneath the main road to avoid a level crossing of the two traffic streams. The airport roads are laid out for one-way traffic and are 7·5m wide. Those surfaces carrying moving traffic are concrete, while parking spaces are asphalted, thereby distinguishing the two kinds of road area clearly. The roads were built on a 20cm thick frost-resisting gravel foundation on which was placed a double load-carrying layer 30cm thick, the lower part of which consists of graded gravel, the upper of two sizes of gravel with graded limestone crushings. The top concrete was put down in two layers, 17cm and 5cm, with size A50 steel mesh between in order to increase resistance to cracking. In the case of the asphalt surfaces the foundation is the same but 20cm of macadam and 5cm of bitumen are placed on top. Normal parking facilities are sufficient for 650 cars including eighty cars belonging to staff members. Additional grass parking spaces are available. The total concrete road area is 13,360 square metres, sidewalks total 5380 square metres, asphalted road surface amounts to 23,400 square metres, and there are grass spaces of approximately 222,000 square metres with several hundred trees and 8500 bushes.

Apron.—The apron was begun at the same time as the terminal building, in the spring of 1957. Carried out in two stages, it totals 103,000 square metres. Construction involved solidifying the excavation in the grown subsoil to an average CBR value of 30, placing on it a 20cm thick frost-resisting layer of coarse gravel (average CBR=42), overtopped by one layer of graded gravel and a second one of two gravel gradings and two gradings of crushed limestone, solidified to an average CBR value of 95 ; a 3cm thick bedding of sand ; one layer of motorway paper ; and a 24cm thick concrete deck. The concrete consisted of fully-dowelled slabs 10m by 3·75m. It was placed in two layers, 19cm and 5cm thick with steel mesh between. Concrete for the under layer had 330 kg per cubic metre of cement, a compressive strength of 300 kg per square centimetre and a bending resistance of 55 kg per square centimetre. The top concrete had a compressive strength of 350 kg per square centimetre and the same bending resistance. The apron is designed for aircraft with all-up weights of 75 tonnes in the case of two-wheel undercarriages and 134 tonnes with four-wheel undercarriages. Slopes varying between 0·40 and 1·51 per cent are incorporated to drain rainwater at maximum rate of rainfall of 122 litres per hectare per second. Provision was made for the possible later installation of an underground system of fuel lines to the jet aircraft parking positions. Water and electrical points and telephones are already provided.

Lighting is by means of nine batteries of floodlights, one on the control tower and eight on 22m high tripod masts spaced approximately 100m in front of the building. Twelve 1000W floodlights are mounted on each mast, giving an illumination of 25 lux at a distance of 100m.

The standings for heavy airliners are in 15cm thick prestressed concrete on foundations as previously described. A total of eighteen aircraft parking positions is provided.

Runways.—The weight of aircraft has nearly doubled in the last ten years (Boeing "707-320," 137 tonnes ; Tupolev "114," 180 tonnes). As far as runway surface stresses are concerned, they are not markedly increased as the load is being spread over a larger number of wheels, but much greater demands are made upon the load-carrying capacity of the foundation layers and the subsoil. An important consideration is the fact that jet exhausts with temperatures of 200 deg. Cent (idling) to 370 deg. Cent. (starting) impinge upon the concrete at velocities of about 200 km per hour. Burning fuel may also fall on the concrete which must not disintegrate as small fragments could be sucked into the jet engines and cause damage. However, the only points which in fact do not adequately resist the hot gases are the bituminous joints which are softened and eroded ; one tries therefore to keep their number to a minimum.

Large continuous slabs can at present be constructed satisfactorily by employing prestressing. This method was first adopted experimentally at Lucany in France in 1945, and has since been used extensively.

All over Schwechat airport soil conditions are fairly uniform. Under 0·5m to 1·0m of humus are 1·5m to 2·0m of loess and underneath, sands and gravels down to a depth of 10m to 15m, and finally, clay. The groundwater table is 20m below the surface although some of the gravels are waterbearing.

Frosts at Schwechat can be severe. For this reason a runway construction with a total thickness of about 0·8m was chosen, comprising a frost protection layer of coarse gravel 20cm to 30cm thick, with a CBR value of 30. This is followed by a 30cm supporting stratum comprising an under layer of graded gravel and an upper layer of two gradings of gravel and two of limestone splittings compacted to a CBR value of 80. On top of this is a 2cm bedding layer of sand covered with building paper. On this the concrete is placed.

The 1500m by 60m concrete runway which the FWB found in existence when it took over the airfield, was repaired and extended to 2000m in 1954, i.e. by 300m by 60m in the West and 200m by 60m in the East. New 23m wide taxiways connecting the runway ends with the apron were also built. The worst sections of the old concrete were replaced and the whole of the old part strengthened with 13cm of black top. The western runway extension consists of 24cm thick plain reinforced concrete in the form of slabs 10m by 3·75m dowelled on all sides. The eastern extension is in the form of two prestressed sections, each 96·25m long by 59·50m broad, together with two 3·75m wide transverse strips, one between the two sections and the other between the existing part of the runway and the adjoining extension section. Each prestressed section consists of fourteen strips 3·75m wide, and two edge strips 3·5m wide. The edges are given 0·25m wide concrete strips to cover the prestressing anchorages.

The 96·25m by 3·75m strips are prestressed

by means of cables, each comprising thirty-two wires of 5mm diameter sheathed in metal ducts. After tensioning, the cables are grouted in. There are two longitudinal cables in the neutral plane of the strip, and transverse cables arranged near the bottom of the section and spaced every 4m. The transverse cables are extended through the two strips of concrete edging between which the joint is formed, into the next strip. The joints consist of soft fibre board with an asphalt filling at the top ; they are held together by the lateral prestress. Surface gradients are small in both transverse and longitudinal directions.

A further extension on the eastern side was carried out in 1959/60, bringing the total runway length to 3000m.

This most recent extension comprises eight sections, each 121m long between which there are transverse strips alternately 1m and 2m wide. A width of 45m, i.e. six 7·5m wide strips is in prestressed concrete. Additionally there is a 7·5m black-top shoulder on each side, raising the overall width to 60m. At the eastern end where the taxiway joins the runway, the black-top strips are replaced by concrete over a length of 200m. The taxiway itself has a 22·5m wide concrete deck, mostly prestressed, with 7m wide black-top shoulders on each side. At the runway there is a 180 deg. bend with a diametral concrete overtaking section without black-top shoulders.

The foundation structure is the same as before, only more compacted, the subsoil to CBR 20, the frost-protection layer to CBR 35, and the load-bearing gravel layer to CBR 85. On this gravel layer are placed 3cm of sand and either a 26cm thick plain reinforced concrete slab, or a 15cm thick prestressed slab.

The black-top shoulders consist of 5cm of asphalt concrete on 15cm thick macadam which in turn is supported by the normal gravel foundation. The stopping area at the eastern end has the same foundations as the concrete runway itself.

The 45m wide concrete of the 1000m long extension is prestressed both longitudinally and transversely by means of 5mm diameter steel wires. The longitudinal cables are anchored in alternate transverse concrete strips over lengths of about 245m. The 45m width is subdivided into six 7·5m wide strips, each with eighty wires in two layers. Prestress was applied gradually as the concrete hardened. The transverse prestressing wires were sheathed and grouted after hardening of the concrete. They lie in the neutral plane of the slab, between the two longitudinal layers of wire.

The gaps between the 121m-sections were kept open until the main shrinkage and creep had taken place. Flat presses were then applied to widen the gaps further which were then concreted, so that upon releasing the pressure the joints were put under compression. Extra longitudinal support against excessive temperature stresses is provided by 19m long and 2m deep serrated abutments.

The longitudinal joints are compressed by the transverse prestressing, but in order to achieve perfect water-tightness, an 8mm wide and 20mm deep groove was cut and filled with plastic mortar.

The eastward extension of the taxiway was constructed in the same manner as the runway. The parking area for jet airliners is also built up of prestressed strips 7·5m width.

Achema Chemical Engineering Exhibition

No. II—(*Concluded from page* 35, *July* 7, 1961)

Rittershaus and Blecher

AUTOMATIC filter presses with up to 100 chambers and plate sizes 1500mm by 1500mm (59in by 59in) were exhibited by Rittershaus and Blecher, Wuppertal-Barmen, Besenbruchstrasse 4-18. The filters are hung on runners from a horizontal beam consisting of two I-section girders. The two platens of the press are connected by four tie-rods, each operated by individual hydraulic cylinders. The plates are equipped with pull-through filter cloths and with the right grade of cloth an almost entirely automatic separation of filter cake takes place. For operation under high pressures the plates are equipped with perforated supports to avoid the filter cloth penetrating into the ribbing and at the same time, guaranteeing a free passage for the filtrate. The automatic plate transporting unit mounted on the support beam consists of an electrically driven endless double chain and plate pick-up hooks. Only one plate is transported and discharged at a time. A photo-electric device safeguards the operator who, thanks to the automatic discharge and built-in time switch, can attend a whole battery of presses.

Large automatic filter presses of this kind (first shown at the 1958 Achema) have recently been successfully employed for dewatering sludge in a pilot effluent purification plant of the Emscher-Genossenschaft, Essen. After a preliminary settlement of eight hours, the raw sludge with a water content of 85 to 90 per cent is dewatered to about 40 per cent water content in forty-five minutes, under a pressure of 15 atm. gauge. The dewatered material is burned directly in the boilers of a neighbouring power station. The water which is drained off is practically free from solid matter. It is claimed that this method may supersede the drying of sludge in large open-air beds for which suitable sites are increasingly difficult to find in densely settled industrial districts like the Rhur.

Pentax

Pentax Maschinen und Apparatebau Ernst A. Reiffen, Kassel-Wilhelmshöhe, showed its multi-frequency stirrers for which the company has developed a new mixing impeller. This incorporates a toothed impeller disc rigidly attached to the drive shaft, and surrounded by a cage with axial intakes at both ends and a peripheral outlet. The cage is mounted on a sleeve surrounding the shaft but normally not in contact with end. Near its end, a journal bearing is, however, provided so as to support the shaft against excessive lateral forces. The design lends itself to the use of guide inlet pipes. These in the case of deep containers ensure thorough mixing by guiding the liquid from both top and bottom to the impeller. Models suitable for containers from 3 litres to 7000 litres are available.

B. Thies

B. Thies Spezialmaschinenfabrik, Coesfeld (Westf.), exhibited a reaction vessel fitted with two helical screw feeds which maintain a fine mutual clearance and only 2mm clearance between themselves and the housing. The equipment has been fabricated out of 18/10 chrome-nickel-molybdenum steel.

Fritz Voltz Sohn

Counterflow heat exchangers with flat tube elements assembled into a round casing were exhibited by Fritz Voltz Sohn, Frankfurt/m. (West.) Solmsstr, 56-68. These are claimed to give better heat transfer with lower pressure losses, and are easier to clean. Units of up to 150 square metres area are stated to be possible, if broad tubes are used.

Friedrich Uhde G.m.b.H.

A glandless drive for an autoclave stirrer was shown by Friedrich Uhde G.m.b.H., Postfach 425, Hagen (Westf.). This uses a magnetic coupling in the form of a bell-shaped permanent magnet surrounding a magnetic armature but separated from it by a pressure-tight sleeve. The same firm demonstrated a twin plunger pump with hydraulic drive. The pump plungers are arranged in line facing each other, and are driven by an oil pump with variable output which actuates a hydraulic cylinder. This imparts an oscillating movement to the plungers with a 180 deg. difference in phase leading to even operation without drops in volume or pressure. Plungers and hydraulic cylinder are kept entirely separate so as to avoid any possibility of contamination with oil. By varying the number of strokes per minute, output may be increased or lessened ; the stroke remains unaltered which avoids local wear of the cylinders, and maintains constant the dead volume, a fact which improves the accuracy of dosing at high pressures. Pressures up to 6000 atm. can be generated.

Probst and Class

For comminuting and dispersing a large range of substances in liquid or pasty media, Probst and Class, Rastatt, Baden, P.O.B. 228, showed versions of its "Vikosator" colloidal mill, a machine based on hydro-dynamic effects. The material passes through a hopper into a rotor-impeller with external square section helical grooves, running at 3000 r.p.m. inside a similarly grooved housing. The gap between the two, which is the zone where the grinding and dispersion take place, can be adjusted, during operation if required, to as fine as 30 micron. The equipment can be set up for batch or continuous

Laboratory colloidal mill—Probst and Class

production with or without recycling. With an installed horsepower of 5·5 h.p. to 22 h.p., output according to model is from 80 kg to 800 kg per hour.

A laboratory version has been introduced and is illustrated above.

Orlita K.G.

Dosing with an accuracy of 0·1 per cent or better, in quantities as low as 1 cubic centimetre per hour and at pressures of up to 2000 atm and over can, it is stated, be carried out with dosing pumps put on the market by Orlita K.G., Giessen/Lahn, Max-Eydth-Strasse 10. The pumps are built as plunger pumps on the unit construction system, and have a stepless linear volume control by micrometer over a range of 100 : 1 or more. This control may be carried out by hand or from a distance. Glandless separation of the—possibly aggressive—fluid to be pumped from the working medium, can be achieved by letting a plunger pump filled with a suitable working medium operate a membrane or bellows pump. Any leakage loss in the gland of the plunger pump is in this case automatically replaced so that accuracy is maintained. The delivery volume of the plunger pump is varied by adjusting the suction space by means of a second plunger which projects into it and which can be advanced or retracted with a micrometer screw. With plungers from 7mm to 120mm diameter, maximum deliveries range from 13·8 litres to 4070 litres per hour.

CONTINENTAL AFFAIRS *(Continued)*

Edm. Gressel A.G.

Standardised constructional elements for pipework lined with hard vulcanised rubber were shown by Edm. Gressel A.G., Aadorf, Switzerland. The interest of the system lies in the fact that all parts are interchangeable and comprise straights in geometrically graded lengths, 90 deg. and 45 deg. bends, tees and crosses, and flanged joints. The flanges are loose and in this way can be rotated into any convenient position. The pipe ends are reinforced by welded-on rings, the lining being carried to the outer edge of these rings. The flanges are pushed over the rings and held back by retaining clips opening into grooves on the flange rings and bearing against shoulders on the flanges themselves. Joints are sealed by gaskets inserted between the pipe ends.

A novel glueing method permits the preparation on site of accurate fitting pieces. The final straight section is bored and turned inside and out so as to enable a special flange to be slipped on, the rubber lining of which continues on the bore as a tapering lip. This laps the lining and the whole of the flange ring is glued into position. The system is available for pipe sizes of 25mm to 100mm.

Flux-Gerate Gesellschaft m.b.H.

A portable electric pump for pumping liquid out of barrels and tanks has been introduced by Flux-Geräte Gesellschaft m.b.H., Stuttgart-Botnang. The pump weighs about 7·5 kg and can pump up to 8000 litres per hour. The maximum head is 8m of water column. The pump is explosion proof and can handle liquids with viscosities up to 100 deg. Engler. The 700mm long pump stem, which has an impeller at the bottom with motor at the top, is inserted into the container. Versions made from various materials are available for use with different corrosive and aggressive fluids.

Emile Egger and Co. A.G.

An improved design of centrifugal pump was shown by Emile Egger and Co. A.G., Cressier (NE), Switzerland. The "Turo" pump is intended for the pumping of clean water as well as effluents, in particular those carrying long-stranded textile and rubber wastes, and industrial suspensions of all kinds with solid percentages of 12 per cent or over. Sand, cement or clay slurries containing up to 60 per cent of solids can also be pumped, as well as oils containing abrasive, coal slurries, &c. The pump is built in sizes covering a range of outputs from 1 to 1800 cubic metres per hour, and heads from 0·75m to 66m of water, corresponding to pipes of 25mm to 300mm diameter, and impeller diameters of 90mm to 430mm at 3000 r.p.m.

The principle places the impeller back out of the mainstream of the liquid, by contrast with the traditional centrifugal pump where all the liquid flows through the impeller itself. It is claimed that hydraulic losses are decreased and that thickeners and solids are carried without encountering any restriction. Friction is lessened and the absence of shocks and restriction results, it is claimed, in less wear and axial thrust, and absence of cavities even with a large suction head.

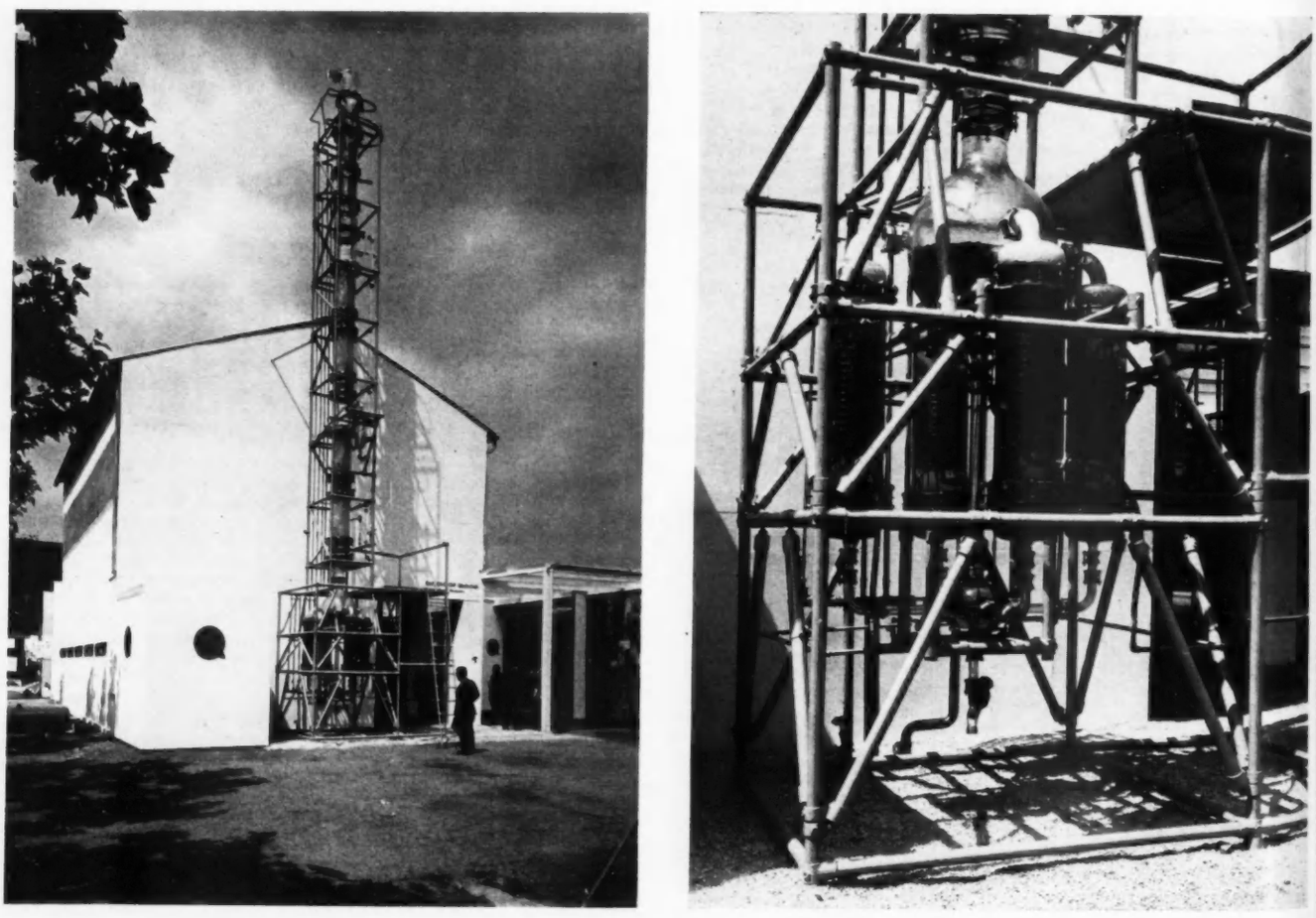
The same company has developed a control valve on the principle of the iris diaphragm, comprising six similar segments each subtending an angle of 60 deg. at the corner. Together they form a hexagonal opening the area of which can be varied continuously from zero to full nominal bore by sliding the segments along the diagonals of the hexagon. This is effected by roller cams on a ring engaging with slots in the segments, the ring being rotated by a tangential screw spindle or worm and worm wheel. The movement may be carried out by hand or under remote control by an electric motor or a pneumatic cylinder. The diaphragm segments are guided each on its two neighbours and are self-cleaning ; the flow can be in either direction. Every valve position can be reproduced accurately enabling the valve to be used as a variable orifice plate for flow metering. Compared with standard valve design the iris diaphragm valve is claimed to have extremely low resistance coefficients (zeta values) at all degrees of opening.

E. Rittershofer K.G.

Apparatebau-Gesellschaft E. Rittershofer K.G., Karlsruhe-Durlach, Weingartener Strasse 1, introduced a glandless pump for discharging acid and other aggressive liquids from containers. The pump is made of polyvinyl chloride or other rust- and acid-proof material and normally dips up to 1000mm into the container which is to be emptied. The 300W or 500W motor, with combined handgrip and switch, can also be supplied in an explosion-proof version. A protective cut-out is incorporated. The pump impeller can easily be exchanged for a stirrer.

Q.V.F., Ltd.

Large chemical apparatus constructed in glass was exhibited by Q.V.F., Ltd., Duke Street, Fenton, Stoke-on-Trent. Our illustrations below give a good impression of what is now being achieved in this medium. It shows a fractionating column 18in in diameter and 40ft high, with four boilers each having a surface of 25 square feet.



(Left)—40ft high 18in diameter fractionating column in glass, equipped with (right) four 25 sq. ft. glass boiler units—Q.V.F., Ltd.

F. LADENDORF

The firm F. Ladendorf, Hamburg 39, Mühlenkamp 59, showed a dosing pump for aggressive liquids, the principle of which consists in the liquid, which is contained in a flexible hose, being squeezed in the direction of pumping by rollers. The hose is arranged in a semi-circle inside a housing. Two planetary rollers are mounted on an arm which is rotated about a central axis.

THEODOR HOELSCHER

Inclined disc rotor pumps for viscous media and doughs were exhibited by Theodor Hoelscher Maschinenfabrik G. Neidl, West Berlin, N.65, Uferstrasse 6. These pumps, for which the U.K. agent is Theodor Hoelscher, Ltd., 91, Shaftesbury Avenue, London, W.1, are also manufactured under licence by Keith Engineering (Aust.) Pty., Ltd., 177, O'Riordan Street, Mascot, Sydney. The pumps are stated to be non-coking and therefore particularly suitable for liquids containing fibrous and other matter (sewage). Where disintegration as well as pumping is required, the inclined rotor disc has a serrated edge and revolves in a pump housing which is provided with circumferential serrations matching those of the disc but with a certain clearance. The successive penetrations of the rotor serrations into those of the housing bring about the disintegration desired.

LEYBOLD

Laboratory and production plant for molecular distillation, with throughputs ranging from 20 g to 880 kg per hour, was shown by Leybold-Hochvakuum-Anlagen G.m.b.H., Cologne-Bayenthal, Bonner Strasse 504. This process, which has very quickly become a valuable industrial tool, limits greatly the temperature to which the product is exposed. The time during which the substances are subjected to heating is also very much shortened. Since the working pressure is of the order of 10^{-5}mm Hg it is essential to de-gas the product completely if the process is to run continuously, and a suitable de-gassing stage is incorporated.

The company is one of the pioneers of the freeze-drying of foodstuffs. At the Achema it showed the model of a 5 ton per day plant built on the unit system and capable of extension. The products are contained in dry air or a protective atmosphere. Automatic control based on barometric measurements is incorporated. Also shown was a laboratory freeze-dryer with radio-frequency heating for experimental use or small-scale production of biological or pharmaceutical preparations.

W. C. 'T HART AND ZN.

Eighty pressure levels are obtainable, up to 3280 kg per square centimetre (49,200 lb per square inch) with a pressure balance (deadweight gauge) shown by W. C. 't Hart and Zn, Rotterdam, Postbus 3002 (U.K. agent : Apex Construction, Ltd., 15, Soho Square, London, W.1.). The range is set by applying mechanically (not by hand) eight weights in various combinations. A reciprocating intensifier pump generates the pressure required. Hysteresis effects are avoided by incorporating a shut-off valve. The weight assembly is continuously driven by a motor, thus reducing friction. An accuracy of 1 in 2000 or better is claimed.

The same firm showed compressed-air-operated hydraulic pumps which are mainly intended for the carrying out of pressure tests on hydraulic equipment. A pressure drop (from whatever cause) automatically restarts the pump while the preset maximum pressure cannot be exceeded, it is stated. Various ranges up to 2100 kg per square centimetre are available.

SIEMENS

Exhibits of the Siemens concern (Siemens and Halske AG, Berlin-Munich, and Siemens-Schuckertwerke AG, Berlin-Erlangen) were shown in a separate pavilion while additional standspace was taken up in the adjoining Hall 10 " Nuclear Science and Technology."

A major point of interest was the industrial application of silicon rectifiers. For electrolysis, Siemens-Schukertwerke showed a silicon rectifier group giving an output of 10,000A d.c. at 900V. Also exhibited were a number of silicon cells with medium and high blocking capacity. Also shown were stepless transductor-controlled constant-current silicon rectifier installation, the model of an average-current control equipment, and a three-point controller with minimum number of relay operations, for the electrode control of a reducing furnace.

Peculiar to the chemical industry are electric drives for large, slow-running compressors. Here Siemens showed applications of its " Simatic " electronic control system, e.g. the digital measurement of angles, and a contactless automatic starter for synchronous motors. Direct-current drives with transductor-controlled supply and frequency-controlled three-phase drives were shown, the latter comprising a synchronous generator driven by a variable-speed, shunt-wound three-phase motor, and supplying with three-phase current of variable frequency several small motors which are to be kept in absolute synchronisation.

Siemens and Halske showed punched-tape programme controller (a digital timer) in conjunction with electro-pneumatic control units " Teleperm-Telepneu." An electro-pneumatic compensating recorder, and a miniaturised electric recorder were shown. The latter can be equipped with up to five selector positions. A signalling system was demonstrated which out of a number of physical measurements selects the one which becomes critical in a particular process, and indicates it first. An electro-magnetic transductor has been developed in which a rotating permanent magnet transmits the indications of a manometer or similar pointer instrument by altering the flux distribution in a ring core. This is measured and amplified, and fed back to a compensating coil. The compensating current is a measure of the instrument reading.

A pH-flow transductor has been developed for liquids which tend to settle. Its glass electrode is periodically cleaned by a motor-driven wiper.

ELLIOTT BROTHERS

Shown at the stand of its associated company Consolidated Electrodynamics Corporation G.m.b.H., were mass spectrometers made by Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13. While some of these were for research use in the laboratory, we confine ourselves here to the model " 21-620A," for process analysis of liquid or gaseous samples which can be as small as 0·1 c.c. of gas or 0·001 c.c. of liquids. In this equipment, an additional electrostatic field causes the ions to follow a cycloidal trajectory. A particular group of ions is made to strike the collector by adjustment of this field. In this manner the mass range 12 to 150 is covered, while a mass range 2 to 12 is covered in the conventional manner by an auxiliary, 180-deg. collector.

In monitoring applications a 99 per cent response is obtained with an instantaneous change in component in about one second. A spectrum scan from mass 12 to 150 takes about thirty minutes.

Applications include the maintenance of correct proportions between hydrogen sulphide and sulphur dioxide in a sulphur plant. The sulphur dioxide is produced by partially burning the hydrogen sulphide. When the two gases are reacted, elemental sulphur is formed. With the spectrometer an excess of either gas can be avoided which would not only lead to loss of output but create a serious air pollution problem. Another application is the analysis of gases given off by vacuum-melted metals which gives a guide to the progress of the process.

SARTORIUS

Sartorius-Werke AG, Göttingen, Weender Landstrasse 96-102, showed its range of precision and analytical balances, introducing an electronic microbalance with maximum capacity of 1 g and a sensitivity of ±1 microgram. The principle of electrical compensation permits the weighings to be continuously indicated and recorded on a commercial recorder. A sedimentation balance automatically measures and records gram size distribution over a range of 1 to 60 micron.

Swedish Steel Works Opened

On June 17, Sweden's latest steel works, Oxelösund, was officially inaugurated. Owned by the Grängesberg Company which spent some Kr.600 million (£41,000,000) on its development—the largest investment ever made by private Swedish industry in one specific project—Oxelösund is an integrated steel plant capable of an output of 300,000 tons per annum. It is the only plant designed to produce a single product, viz. high grade heavy plate.

Situated on the Baltic south of Stockholm, the town of Oxelösund has for long been the port of the Grängesberg ore carrier fleet which here load the ore from the company's central-Swedish mines. A 40-year-old plant including a pig-iron and sponge-iron plant and a window glass works were acquired there in 1955. There was ample scope for future expansion, leading to a doubling of the population from 6000 to 12,000.

When deciding to add a major production unit to its activities which previously had mainly been those of a producer of ore and a shipping company, Grängesberg decided upon the manufacture of plate as the demand for this class of product has in recent years risen to a spectacular extent. In 1955, Sweden's output of heavy plate totalled 129,000 tons, imports amounting to 244,000 tons. In 1960, the respective figures rose to 257,000 and 310,000 tons. Most of the increase in demand came from shipyards, the building industry, and manufacturers of pipes for pipelines and of machinery.

Starting from scratch gave Grängesberg the opportunity to employ new methods. It adopted the Kaldo oxygen process developed by Professor Bo Kalling at the Stora Kopparberg Company's Domnarfvet steel works and at that time in operation on only a minor scale. This process is claimed to be suitable for high as well as low phosphorous iron.

The Oxelösund plant has two 100-ton rotary Kaldo converters for an annual output of 300,000 tons of crude steel. In addition there is a 150-ton open-hearth furnace with an annual capacity of 135,000 tons, which is intended principally for the conversion of edge cuts and other return scrap from the rolling process, amounting to about 35 per cent of the steel input to the rolling mill.

When in full operation, the plant—new and old establishments together—will consume an annual 800,000 tons of ore—mainly from the company's own mines at Grängesberg and Stråssa, 450,000 tons of coal, 190,000 tons of lime and dolomite, and 60,000 tons of oil. Most of these supplies will be brought in by the company's own rail and shipping facilities. Besides the 300,000 tons of heavy plate, output will comprise 125,000 tons of pig iron, 30,000 tons of sponge iron, and 430,000 cases of window glass (or about half the total Swedish production).

The 25m high, 7m diameter blast-furnace has a capacity of 1200 tons in twenty-four hours and is claimed to be the largest in Scandinavia. It is fed with ore sinter and coke by means of conveyor belts.

The steel works represent a steel structure of 9000 tons, the 54,000 square metres rolling mill with a length of 540m, is stated to be the largest single industrial building in Sweden. Over 10 miles of conveyor belts are installed.

Inland Ship Standardisation

According to the German Productivity Council (RKW), proposals for standardising the designs of ships for inland waterways are to be worked out by expert committees within the framework of the European Economic Community. It is the intention to reduce the number of ship designs from about twenty to five, and to change from the comparatively expensive one-off construction to series production. The advantages of standardising on few designs extend to diesel engines of which there are now well over 100 different designs in existence, and to equipment, auxiliary engines, winches and other machinery, and the required spare parts, as well as ships' plates and rolled sections. Investigations are to commence in the near future at Belgian, Dutch, French and German shipyards into the extent of savings which would accrue. This follows the project of standardising the inland waterways, a matter which is already being tackled.

THE AMERICAN SCENE

By Our American Editor

Large Diameter Welded Steel Pipe Mill in Pennsylvania

HIGH-STRENGTH, large-diameter steel pipe for the cross-country transmission of high-pressure natural gas is now being produced at an expanded line pipe mill installed at the Bethlehem Steel Company, in Steelton, Pennsylvania. The new mill is expected to triple gas pipe production at the Steelton works. Approximately 25,000 tons of line pipe ranging from 18in to 42in in outside diameter can be produced per month. Before the mill went into operation, Bethlehem produced this pipe by first rolling 20ft lengths of steel plate into cylindrical form, and then butt welding two sections together to form the standard 40ft length of gas transmission pipe. Now, the company forms this pipe on two large presses. The first is a 2500-ton hydraulic " U "-ing press and transforms a 40ft length of steel plate, up to ¾in thick, into a long " U " in less than a minute. The second one is an 18,000-ton hydraulic press, and requires another minute to complete the shape, turning the " U " into an " O." This quick forming process is the key to the rapid production of high-quality pipe at rates up to one 40ft length every two to three minutes.

Plate Preparation

Material for forming the line pipe arrives by rail at the Steelton mill from either the Sparrows Point or the Johnstown plate mills of Bethlehem. The plate measures 40ft 5in long and 52in to 130in wide, depending upon the diameter of the finished pipe. The plate arrives deliberately oversize, since it loses a few inches in width and length as it is processed down the 1000ft long production line. The weight per plate varies from 1 ton for the 18in stock to 7½ tons for the42in size.

Stacks of plate are unloaded from the railway cars by a 20-ton magnet gantry crane and placed on either side of a receiving table, just outside of the 930ft long mill building. A one-legged gantry of 15 tons capacity, equipped with suction cups, then vacuum-lifts one plate at a time and places it on the receiving table. Powered rolls move the plate from the receiving table to the feeding table, one at a time. When the last plate of the stack actuates a limit switch, the one-legged gantry automatically stops in the home position. The gantry is then switched over to pick steel from the other stack of plates. A one-legged gantry was chosen to feed the receiving table because it always gives the magnet gantry crane access to stack the plate on one side of the receiving table or the other.

The feeding table moves the plate along, through a slit in the side of the building, directly to the side planer. The side planer removes approximately 1in on each side of the plate with twelve cutting tools. Both sides are planed simultaneously in about two minutes. The plate then rolls to an end planer where four photo-electric cells automatically stop it in the proper position for cutting to size. The plate is first clamped and cut on the leading end ; then moved, stopped again by electric eye, and clamped and cut on the trailing end. Hydraulic squaring devices on the end planer ensure a truly rectangular plate, which is essential to obtain a perfect pipe section.

Hydraulic Presses

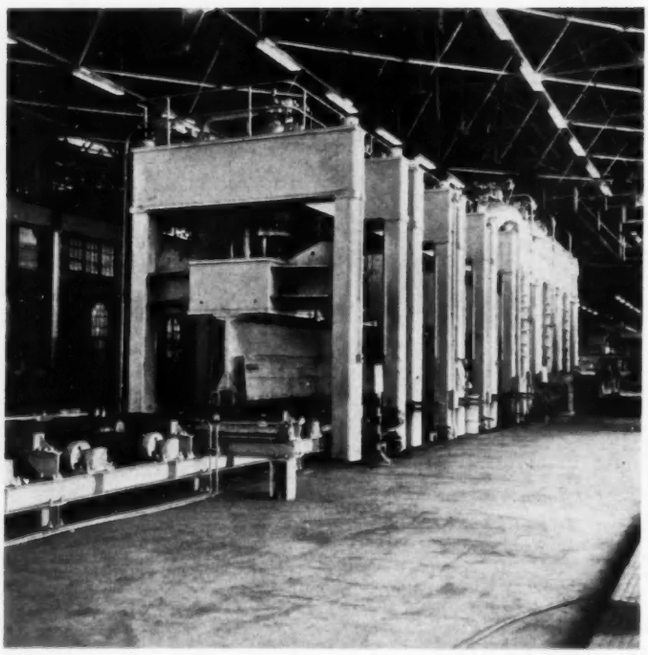
A powered table then feeds this plate to a 2500-ton hydraulic " U "-ing press. In less than one minute, the plate is shaped into a long " U," as the male punch presses downward in the centre of the plate and the rocker die, below, tilts upward on each side. The plate is precisely positioned by limit switches.

The " U "-shaped plate moves directly from the " U "-ing press to the 18,000-ton " O "-ing press and is precisely spotted by an electric eye. In fact, the " O "-ing press contains a total of fourteen photo-electric cells which will not allow the press to operate till the preceding plate is ejected, the top die is fully up, and the press, in general, is ready to receive and form the next plate. A key, mounted at the top of the upper " O "-ing die and running its full length, prevents the plate from spiralling as the die halves come together. In about one minute the " can " emerges, 40ft 5in long and slightly open with a 1in gap running along the top. One man operates both the " U "-ing and " O "-ing presses.

Seam Welding

The " O "-shaped can then is placed in the prepared pipe storage area by cross chains. The can is moved longitudinally by conveyors and then by gravity skid, until it rolls into the end of one of three inside seam welders. By rotation the gap is positioned at the bottom. The can is welded on the inside first and is closed much like a zip fastener. Slitter rolls vary the gap from about 2in at the extreme back end to zero at the weld point of the leading end. The inside seam welding machine can handle 18in to 42in diameter pipes. It deposits a continuous bead by tandem submerged electric arc welding at a rate from 50in to 75in per minute.

The pipe continues its travel and, by gravity skid, is placed on to rotators ahead of the outside seam welders. After positioning the seam at the top, the pipe is fed into one of the three outside seam welders. Again, by tandem submerged electric arc welding, a continuous weld is deposited at a rate from 50in to 75in per minute. The bead is continuous from can to can, so that



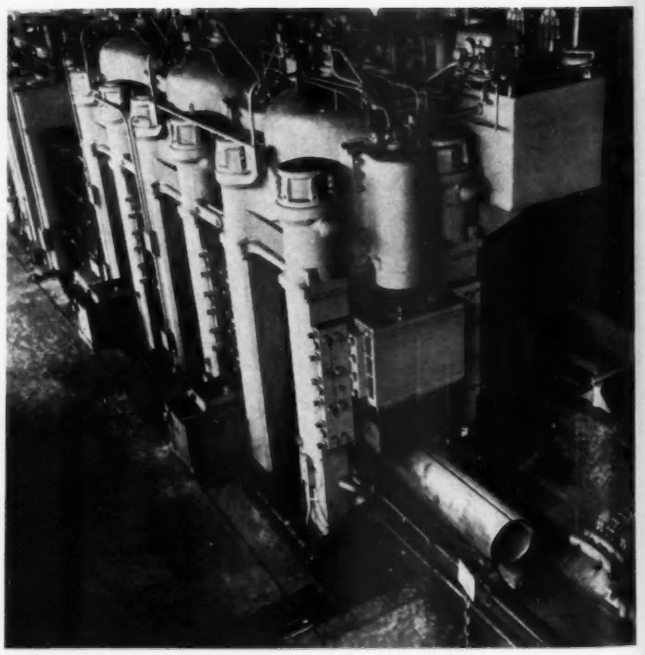


Fig. 1 (Left)—2500-ton hydraulic " U "-ing press for the production of 40ft long pipe. Fig. 2 (Right)—18,000-ton hydraulic " O "-ing press for completing the cylindrical pipe shape

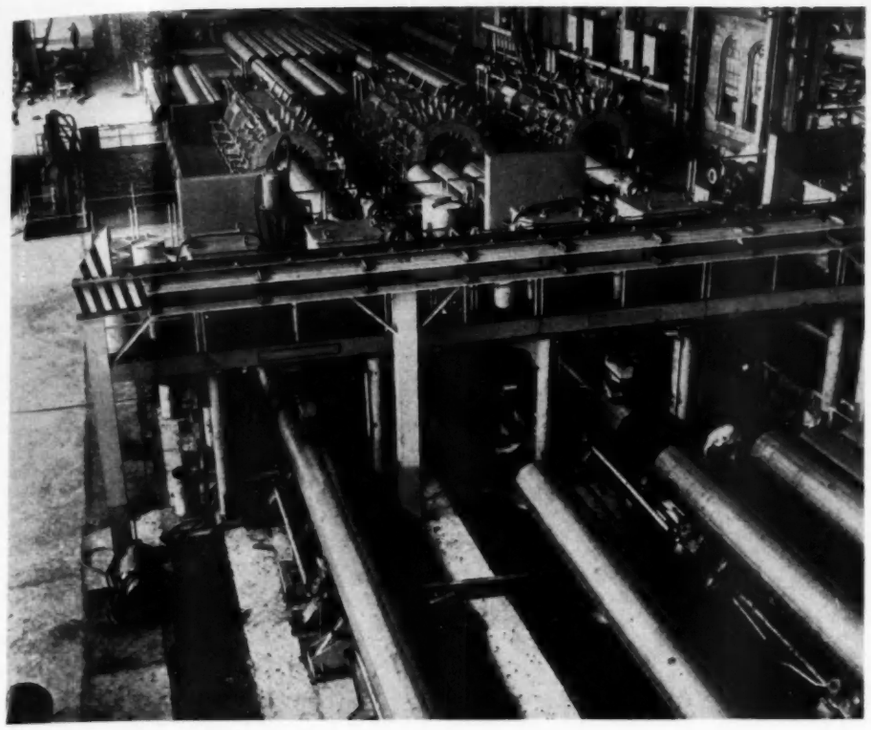


Fig. 3—Tandem submerged arc seam welding machines, with outside welders in the foreground

it is necessary to break off the weld between pipe sections by tilting one section away from the next.

Inspection and Expansion

The next pipe operation—though potentially a bottleneck—is accomplished smoothly by the use of an automatic crane with a built-in memory unit. The pipe sections, coming from the three welding units, must enter a common conveyor line. The sections emerge from the three welders at various intervals and not necessarily in order. The memory unit stores information coming from the welders and automatically records the order in which it will move from welder to welder to deliver pipe to the conveyor line. At the pipe inspection station the pipe and weld are visually inspected. Repair stations are provided for grinding inside weld reinforcement at each end, repairing weld defects and correcting minor surface defects.

A hydraulic cylinder then raises the pipe on to the expander, which has a maximum water pressure capacity of 5700 lb per square inch. This operation enlarges the pipe in circumference from 1in to 2in, shortens it in length by about 5in, gives it a higher yield strength, and tests it for bursting strength and leakage. The pipe is enclosed in a die clamp and lock bar; a mechanical plug with rubber gaskets seals off each end. About 50 gallons of high-pressure water are introduced, and the pipe enlarges to the limit of the die clamp. This procedure ensures obtaining a true, circular pipe with each section of equal diameter. A further test of strength is made while the pipe is still on the expander. The lock bar is taken off, the die clamps are lowered, the water pressure is raised to specification test pressure, and then the pipe is struck with several hammers. The time required for the expansion treatment varies from two minutes to five minutes, depending on the pipe diameter.

Next, the pipe is fed by conveyor to the fluoroscopic inspection station. The pipe rides on a carriage and passes under an operator in a lead-shielded booth. He critically examines the pipe seam continuously at speeds of up to 20ft per minute. Should he detect a flaw in the weld, he presses a button and a dab of paint is applied next to the defect. The repair station takes care of defects; the pipe sections are then gravity-fed to the end facing machine. Here, the ends of each pipe section are bevelled, as a lathe rotates around the stationary pipe. This bevelling is necessary to permit section-to-section butt welding in subsequent field installation.

Final inspection takes place next, with the pipe being visually inspected inside and out. The pipe finally is weighed and measured and loaded for shipment by rail or road.

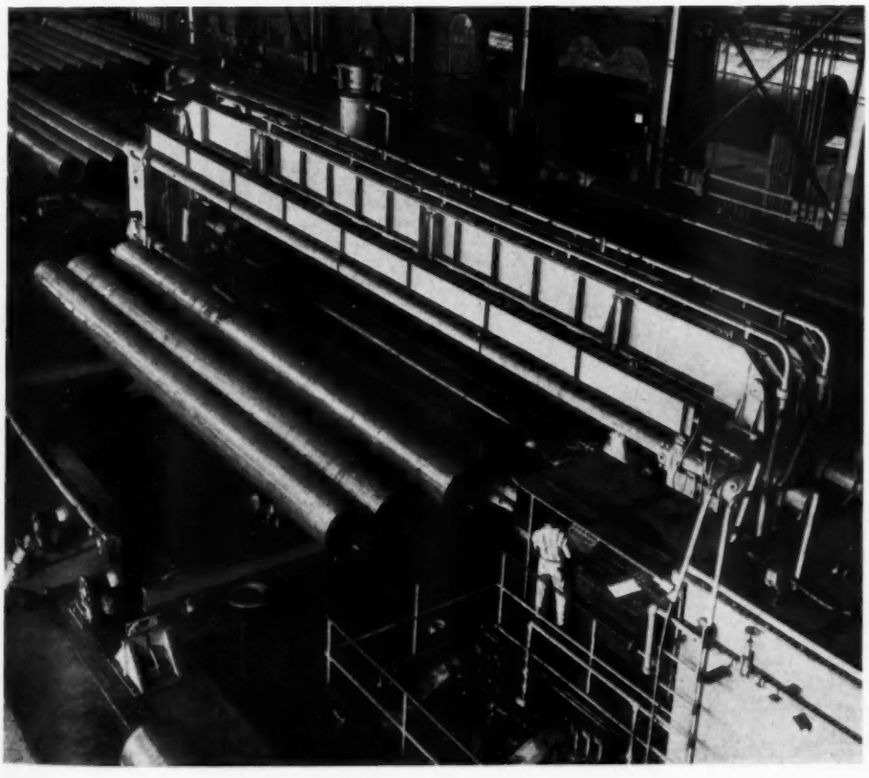


Fig. 4—Hydraulic pipe expanding machine, functioning also as a bursting strength and leakage tester

Electronic Heart Stimulation

Further developments have taken place of a cardiac "pacemaker" by engineers of The General Electric Company as part of a programme to improve such devices and extend their usefulness to other areas of medical electronics. This electronic device, evolved in collaboration with a New York surgeon, provides an electrical impulse that causes the heart to beat in proper rhythm. The electronic aid becomes necessary when the heart's normal impulse, supplied through the body's nervous system, is weakened or destroyed by Stokes-Adams disease.

Pacemakers have been successfully employed for such cases only in recent years. Work began about two years ago when a team of engineers was formed at the Electronics Laboratory to work on medical electronics. When a patient suffering from Stokes-Adams disease was admitted to Maimonides Hospital, work on an improved, implantable heart pacemaker began. In the natural course of the disease, the patient's pulse rate has dropped to twenty beats per minute, barely high enough to sustain life. Normal procedure called for the immediate implant of steel electrodes into the heart tissues to supply impulses. An external pacemaker was employed until the implantable device could be designed and built.

It was specified that the new pacemaker should permit temporary increase in pulse rate for occasions when the patient was engaging in strenuous activities. External control of pulse rate had never before been provided for an implantable device. As reliability was the paramount consideration, the circuitry was kept as simple as possible, and only extremely dependable solid-state devices were used as active components. Before the surgical implant could take place, a working model had to be tested externally for a two-week period to make sure that the impulses of the unit were compatible with the requirements of the patient's heart. While the tests were running, the final model and an operating spare were constructed and encased in an inert plastic. When the surgeon performed the surgical implant, three engineers were in the operation room as members of the surgical team.

The patient is now leading a normal life. Her pacemaker is completely self-contained with a set of batteries that will last from three to five years before requiring replacement. The regular rate of the pacemaker is fixed at sixty-five beats per minute. The patient has a second unit that she can wear if she wants to increase her pulse rate for any reason. This device has a calibrated potentiometer that can be set at any pulse rate from seventy to 125. It is about the size of a miniature transistor radio and has a flat circular antenna which is worn over the spot where the pacemaker is implanted.

THE AMERICAN SCENE *(Continued)*

Electron Beam Welding Installation

A new design of electron beam welder has been developed by Sciaky Brothers, Inc., of Chicago, Illinois, and is presently in operation within the company's welding laboratory facilities, where it is actively engaged in welding various refractory and reactionary metals as well as dissimilar groupings. The vacuum chamber of the machine measures 20in wide by 30in high by 48in long. The electron gun is provided with traverse motion (*Y*-axis) and vertical motion (*Z*-axis) powered by speed and position servo-controls. This control, known as "Sciakydyne," also effects the longitudinal motion (*X*-axis) of the internal worktable.

The vacuum chamber is pumped to 1×10^{-4}mm Hg in about four minutes. The pumping sequence is fully automatic. With atmosphere conditions equal, both end doors can be opened. Also, the 20in diameter front port opens to provide closer accessibility to the electron gun and work area. An electron beam of 350mA at 30kV can be produced by the electron gun and the associated power supply. The beam spot can be focused into a 0·030in minimum diameter and over a 1in maximum diameter.

Electron beam welding is a new fusion welding process with great promise of application in the nuclear and aero-space industries. It is a fusion welding process in which the mechanism of welding is to join two or more pieces of metal by local melting, which results in coalescence. Filler metal and base metal, or base metal only, may be melted together to produce a joint. The heat required for welding is produced by the bombardment of the work by a dense beam of high velocity electrons. The electron beam is directed upon the area to be fused, and the electrons, upon striking the surface of the metal, give up their kinetic energy almost completely in the form of heat energy.

Since a vacuum of the order of 1×10^{-4}mm Hg is needed to produce a stable electron beam, the welded joints are extremely pure and free of absorbed gases. As a result, electron beam welding is well suited for welding the refractory metals, the highly oxidisable metals and the vacuum-melted alloys. However, any weldable metal or alloy, and possibly some ceramics, can be fused by means of this process. In addition to welding by fusion, the process and equipment can be used for melting, grain refining, stress-relieving, out-gassing, cutting, overlaying, metallising, crystal growing and vacuum brazing. Containers enclosed by electron beam welding retain an internal vacuum when removed from the welding chamber.

Dr. J. A. Stohr, Chief of Technical Services of the French Atomic Energy Commission, made the first public disclosure of this Sciaky welding process at the Technical Symposium on Fuel Elements held in Paris on November 23, 1957. Since that time several electron beam welding machines have been put into service in France and in the United States, primarily for the production of fuel elements for nuclear reactors. The original development by Dr. Stohr utilised a work-focused electron gun operated at 25kV. (A work-focused gun is one in which the gun is the cathode, the work the anode, and the workpiece and the gun combine to form the electrostatic lens). Because the electron optics of such a system cannot focus an electron beam to very high specific energy, the weld exhibited a width-to-depth ratio of approximately unity. Subsequently, the electron microscope was adapted for welding. Operating at about 100kV it produced very high specific beam energy and demonstrated the possibility of narrow, deep welds and reduced distortion.

For some time it was generally believed that such narrow, deep welds could only be produced by high-voltage equipment. In fact, the space charge mutual repulsion between electrons in a beam indicates that it is far simpler to produce high specific beam energy at the higher electron voltage. However, Sciaky has recently developed an electron gun that achieves the desired high power density at electron voltages below 30kV without the inherent danger from radiation resulting from very high voltage systems. A series of experiments with this equipment has shown that there is a threshold level of specific beam energy below which the normal laws of heat transfer are fulfilled, and the weld is at least as wide as it is deep. Above this threshold value, energy is imparted to the work at a substantially higher rate than it can be conducted away from the electron beam impact zone; thus, narrow, deep welds result, with up to 12 to 1 depth to width ratio.

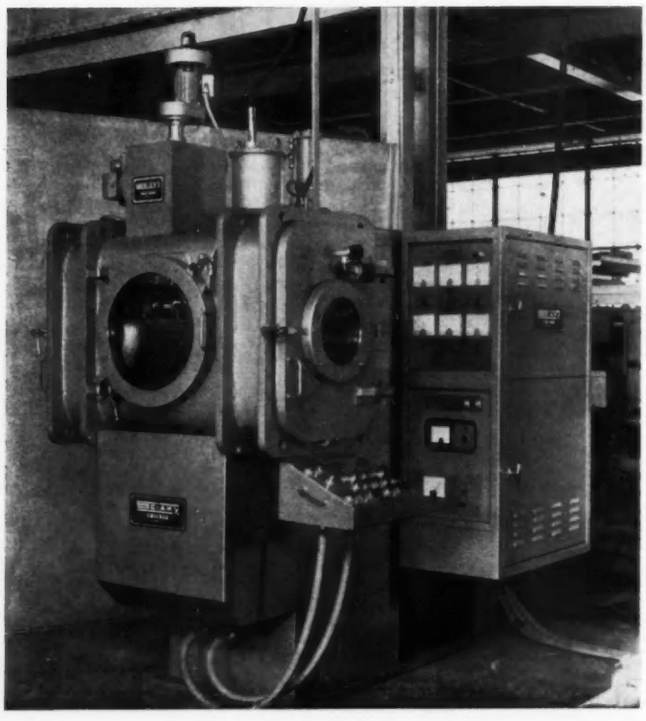
Earlier equipment concepts involved a fixed electron gun outside of the welding chamber. Its limitations soon became apparent, particularly the necessity of moving the workpiece with precision, and the inherent limitations imposed upon the geometry of work that can be welded. This problem prompted a most significant development—placing the gun within the welding chamber. Not only can it now weld in the conventional upright position, from underneath, or at right and oblique angles, but both the gun and fixture can travel while welding. This concept thus takes full advantage of the chamber internal dimensions.

The new Sciaky facility employs a stainless-clad steel vacuum chamber of rectangular configuration, and contains the electron gun and the worktable. The vacuum chamber has three viewing ports—one in the centre, and one in each end of the chamber. The motor-driven mechanisms for controlling the vertical and rotational position of the electron gun are mounted on top of the vacuum chamber, and the driving mechanism for translation of the worktable or rotation of the work-holding chuck is mounted on the bottom of the chamber. The electron gun construction is simple and rugged. Precise alignment is inherent in design, and is not dependent upon assembly adjustments. If necessary, filaments can be easily and quickly replaced in less than five minutes.

A simple spacer arrangement adjusts the gun optical system throughout a wide range of output power without compromise of specific beam energy. The electron gun is bracket-mounted on the lower end of a shaft which also contains the high-voltage leads. By means of this shaft and the mechanism provided, the electron gun can be rotated in a horizontal plane and raised and lowered to an appropriate distance from the work. Positioning of the electron gun can be done without opening the chamber, and while the chamber is evacuated. The "T"-slotted worktable in the chamber mounts on a pair of rigid guide rails with special ball-bearing wheels. Translational motion is imparted from a vertical shaft to the worktable by means of a rack and pinion. The "T"-slotted table can be replaced by the work-holding chuck.

The operator's control station can be situated at the end of the vacuum chamber or at the front of the chamber. The vacuum pumping system is wholly situated within the machine frame, except for the mechanical roughing pump which is mounted at the rear of the machine on a separate base so as to minimise transmission of vibration from the pump to the welding chamber. The high-voltage equipment consists of an oil-filled tank containing a high-voltage transformer and rectifier, and a cabinet containing a motorised variable auto-transformer which controls the input voltage to the high-voltage transformer. The cabinet also includes controls for the high-voltage circuit and meters for the input voltage and input current to the high-voltage transformer.

Great care has been exercised to provide adequate safety provisions to protect the operating and maintenance personnel, and the equipment as well. Furthermore, this equipment presents no hazard with regard to X-ray emission The maximum potential provided by design is 30kV. At this accelerating potential, X-rays are of relatively long wave length and low intensity and are known as "soft." The chamber, doors and ports have been carefully designed so that primary or secondary X-rays will not escape. These direct or scattered X-rays are either trapped or absorbed by the more than adequate thickness of the chamber and the leaded glass and lead gaskets at the ports. Each machine is set up and thoroughly tested before shipment.



Sciaky electron beam welding machine with 30kV capacity and 20in by 30in by 48in vaccuum chamber

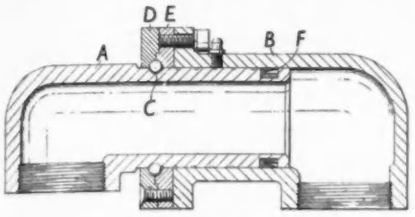
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

PIPE COUPLINGS

871,052. February 11, 1960.—ROTARY PIPE COUPLINGS, J. R. H. Products & Co. Limited, Vale Road, Windsor, Berkshire. *Inventor: John Trevor Nicholas Heygate.*

The drawing shows one form of pipe coupling made in accordance with the invention. An inner pipe *A* is located within an outer pipe *B* to a length of about one and a half times its outer diameter. The outer ends of the pipes are threaded for attachment of steam pipes. The inner pipe has an annular groove *C* in its surface and steel balls in this groove also seat in an annular recess formed half in



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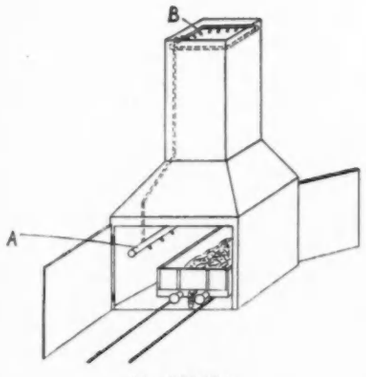
each of two hardened steel collars *D*, *E*, bolted on the outer pipe collar and which closely surround the inner pipe. By removing the bolts the pipes can be separated while the balls which form a ball race are still retained in their grooves. The inner pipe has a groove *F* near its inner end and a packing ring contained in this groove has its open side directed towards the end of the inner pipe so as to receive the pressure from the pipes. A helical groove is cut in the surface of the inner pipe and leads from near the packing ring to the balls. A lubricating nozzle in the outer pipe supplies lubricant to the groove.—*June* 21, 1961.

COKE COOLING TOWERS

871,094. March 7, 1960.—COKE COOLING TOWERS Didier-Werke A.G., Lessingstrasse 16, Wiesbaden, Germany.

The exhaust fumes from coke cooling towers consist of a mixture of water vapour, and air and they carry a noticeable amount of dust. To avoid the nuisance of the dust, it has been suggested to inject water into the chimney section of the cooling tower to wash the fumes. The result achieved by this washing process has however not proved satisfactory. The thermodynamic conditions of the exhaust mixture of steam, condensed vapour in the form of fumes and air are, in effect, such that the complete condensation of water vapour within the crown of the chimney does not succeed, nor are the fumes eliminated sufficiently. The nuisance of the



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dust also remains and the invention aims at overcoming these disadvantages. In the coke cooling tower illustrated it will be seen that doors are provided to prevent the free flow of air into the lower section which receives the coke cooling truck and is fitted with quenching jets *A*. In the chimney preferably adjacent the upper end or crown, are water injectors *B* for injecting into the upward flow of gas, dust etc., a stream of water which serves to wash away the dust and liquefy the supersaturated exhaust fumes. It has been found that if air can be prevented from being sucked into the cooling tower a reduction in the mass and velocity of air flowing makes it possible to cause the condensation of waste gases and the fall out so that in effect air-free saturated water vapour only will pass out of the chimney. This follows from the fact that a smaller volume of gas at a reduced velocity is being washed with the water. This water vapour in the gas may be completely liquefied by water injected at the crown of the cooling tower. An additional advantage lies in that, as a result of the reduction in velocity of the gas stream, the cooling tower may be shortened and it is possible easily to modify existing cooling towers for the purpose of the invention. In a further modification the water injectors of the chimney may be adjustable in position in relation to the top of the tower.—*June* 21, 1961.

MINING EQUIPMENT

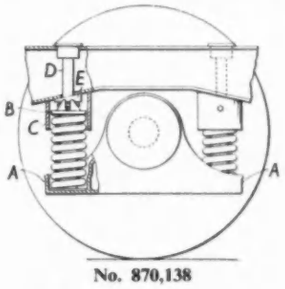
870,514. June 27, 1957.—HYDRAULIC PIT PROPS, Becorit Grubenausbau G.m.b.H., Werkstattenstrasse 13, Recklinghausen, Germany.

According to this invention a hydraulic pit prop has inner and outer members relatively extensible by pressure fluid supplied by a pump driven by an in-built vibratory motor supplied either by a low voltage alternating current or by a chopped direct current. The high rate of reciprocation of the vibratory motor, makes the volumetric stroke of the pump very small even when the output is comparatively large. This presents the advantage that a motor of very small power is adequate to operate the pump, about 24V being sufficient for directly operating such a motor. Drawings accompanying the specification show details of the design of the vibratory motor-driven pump built into the prop.—*June* 14, 1961.

RAILWAY VEHICLES

870,138. July 15, 1958.—BOGIES FOR RAIL VEHICLES, The English Electric Company, Ltd., Queens House, 28 Kingsway, London, W.C.2. (*Inventors: Stanley Clarke Lyon and Maurice Armitage Simpson.*)

This invention relates to a bogie in which the vertical load is transmitted from the frame to the axle boxes through vertical helical compression springs seated at their lower ends on the axle boxes. Referring now to the drawing, the axle is journalled at each end in an axle box with integral spring pan *A* in which are seated helical compression springs. Each



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spring is seated at its upper end on a screwed flanged bush *B* contained in a spring cup *C* projecting down from the bogie frame. The bush is mounted on a screwed spindle *D* which projects up through the frame and terminates in a squared end. The weight of the bogie and superstructure is transmitted to the spindles through bearing seats *E* on the underside of the frame and thrust collars integral with each spindle. A removable plate normally covers the squared end of the spindle. When it is desired to raise the height of the bogie frame relative to the track to compensate for wheel tyre wear etc., it is only necessary to rotate the spindles in the appropriate direction with a spanner.—*June* 14, 1961.

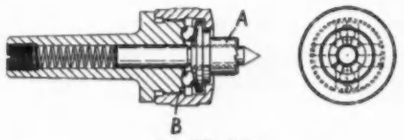
870,339. April 23, 1959.—OUTSIDE BUFFERS FOR RAILWAY VEHICLES, George Spencer Moulton AND Co., Ltd., Bradford-on-Avon, Wiltshire. (*Inventors: Albert George Standbridge and and Jack Burnham.*)

The outside buffer for a railway or like vehicle described in this specification incorporates a column of rubber springs in conjunction with a hydraulic cushion in such a way that during at least the latter part of the stroke of the buffer, shocks are resisted by the hydraulic cushion and the column of rubber springs in parallel. Preferably the hydraulic cushion only operates during the latter part of the stroke of the buffer, the column of rubber springs being compressed alone during the initial part of the stroke. The buffer has a soft start to the stroke while only the rubber springs are being compressed, thereby giving the advantage of a gradual build-up resistance. The rubber springs give a high recoil force to ensure that a measure of cushioning is available under all conditions, while the hydraulic unit allows a high amount of energy absorption under excessive impact loads.—*June* 14, 1961.

MACHINE TOOLS

870,232. December 21, 1959.—FACE DRIVING LATHE CENTRES, Myford Engineering Company, Ltd., Neville Works, Chilwell Road, Beeston, Notts. (*Inventors: Glyn Ceirog Walters Jones and Arthur Leonard Tickner.*)

The object of the invention is to provide a face driving centre which will automatically adjust itself so that the thrust exerted on the work by the driving teeth of the centre is proportionate to the torque exerted on the work by the cutting tool. The centre is a sliding fit in a housing and has around its outer end a face driving member which consists of a sleeve *A*. The outer end of the sleeve has teeth or serrations to cut into the face and drive the work. The inner end of the sleeve is formed with a flange by which the face driving member is held in the housing by a cap. Two diametrically opposed dimples *B* are provided in the outer end face of the housing with a hardened steel ball in each. The balls also engage in diametrically opposed "V" cross-section grooves in the inner face of the flange



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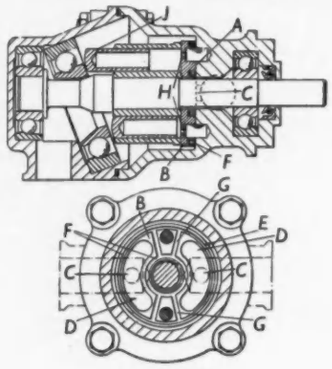
on the face driving member. The inner face of the flange is preferably made frustro-conical to provide for movement of the face driving member so that the driving end of the sleeve can adjust itself to the face of a work piece when on the centre. Pressure exerted on the work piece by the tailstock moves the headstock centre into its housing against the action of its spring and until the teeth on the face driving member have cut into the face of the work sufficiently to drive it. When torque is applied to the work piece, it tends to turn the face driving member. Any relative movement between the housing and sleeve causes the balls to ride up the inclined faces of the dimples and "V" cross-section grooves imparting movement of the face driving member towards the work piece to exert greater driving pressure. As a result the pressure exerted on the work, and consequently on the headstock, spindle bearings will vary according to the torque exerted on the work piece by the cutting tool, and the penetration of the driving teeth does not exceed that necessary to drive against the cutting load. Alternative constructions are shown in the specification.—*June* 14, 1961.

HYDRAULIC PUMPS OR MOTORS

869,905. February 11, 1960.—FLUID PUMPS OR MOTORS, Joseph Lucas (Industries,) Ltd., Great King Street, Birmingham, 19. (*Inventor: Frank George Freeman.*)

In the swash plate pump illustrated there is fitted between the end of the body and a flat transverse surface *A* of the casing an annular valve plate *B* in which are formed a pair of curved apertures *D*. These apertures are concentric with the shaft so that the bores in the body will register in turn with the apertures as the body rotates. Also in the surface *A* there is a pair of ports *C* which are in communication respectively with an inlet and an outlet at opposite sides of the casing, these ports being in register with the apertures in the plate *B*. Between the plate and the casing is a rubber or other resilient sealing

member *E*. This member includes a pair of concentric rings *F* which lie at the inner and outer sides of the apertures *D* in the disc and two pairs of diametrically opposite parts *G* integrally joining the two rings between the apertures. The adjacent face of the plate *B* has complementary grooves to



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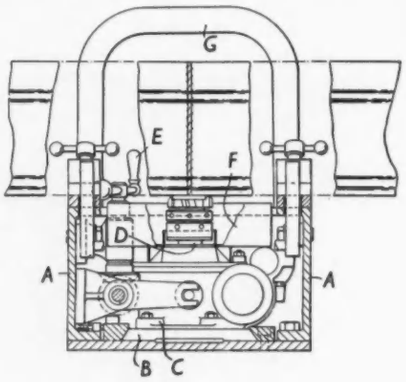
receive a portion of the member *E* and locate it against lateral movement. The depths of the grooves are such that a portion of the member *E* is proud of the face to bear on the adjacent surface of the casing. Moreover, at positions between the pairs of parts *G* respectively a pair of holes *H* extend through the valve plate. The holes contain loosely fitting dowels which serve to locate the plate *B* against lateral or angular movement relative to the casing whilst permitting fluid flow through the holes. In use the pump plungers *J* are moved in one axial direction by the pressure of liquid and are moved in the opposite direction to discharge fuel to the outlet by their interaction with the swash plate. During this operation the resilient member *E* serves as a seal between the disc and the casing. Moreover, as a bore moves from a position in register with one aperture *D* to the other it registers with one of the holes *H* in the disc and thereby permits equalisation of the fluid pressure at opposite sides of the valve plate in the areas bounded by the adjacent pair of parts *G* and the two rings *F* of the sealing member. —*June* 7, 1961.

RAILWAY EQUIPMENT

871,244. October 22, 1957.—TRIMMING RAIL JOINTS, Flextol Engineering Company Limited, Flextol Works, The Green, Ealing, London, W.5. *Inventor : Albert James Wilmot Blake.*

As is known, in the welding of rails to form a continuous track, the rails are laid with a gap between their ends, a metal closure plate (about $\frac{5}{16}$ inch thick) is placed beneath to span the gap before the rails are welded together, the closure plate becoming welded to the underside of the rails. It has been found that the strength of the welded joint is very much increased if this plate is removed and the underside of the joint made flush with the undersurface of the rails. An object of the invention is to provide a portable machine that can be operated on the welded joints of rails *in situ* to remove the plate. The portable



No. 871,244

milling machine provided is clamped to the rail with its frame beneath and with the side members *A* at right angles, one at each side of the welded joint to be trimmed. A bed plate *B* is slidable in guides along the botton plate and on it is fixed a casting *C* in which is mounted a driven vertical shaft *D* on the top of which is mounted a milling cutter. A lead screw rotatable through bevel gearing by a handle *E* moves the bed plate with the milling cutter across the rail to trim off the filler plate beneath the welded joint. Also mounted on the bed plate is a suds pump with a flexible hose leading to the proximity of the cutter. A swarf catcher comprising a removable box *F* is supported from one casing of the cutter shaft and surrounds the cutter. Swarf from the cutting operation is collected in this box whilst the cooling suds pass through the perforated bottom into the receptacle formed by the frame. Lifting handles *G* at each end of the frame are pivoted to the side members so that they can be swung down to lie below the level of the rail or raised to bear against the bars for lifting purposes. The machine is sufficiently narrow to be accommodated between the sleepers supporting the rails, some ballast being scraped out temporarily if necessary to accommodate the height. A feature of the machine is that it lies completely below the running part of the rail so that, if necessary, a train can run over the rail with the machine in position.—*June* 21, 1961.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ROUGHNESS COMPARISON SPECIMENS PART 1 : GROUND FLAT AND CYLINDRICAL TYPES

No. 2634 : Part 1 : 1960. Price 4s. 6d. This standard has been revised in order to embrace both flat- and cylindrically-ground roughness comparison specimens and to ensure that they correspond more closely to those produced in America and Canada. The range of roughness grades has been extended to provide comparison surfaces of 1 CLA (centre-line-average roughness), 2 CLA, 4 CLA, 8 CLA, 16 CLA, 32 CLA, 63 CLA and 125 CLA. Requirements are laid down for dimensions, accuracy, general design and manufacture.

Work is now proceeding which, it is hoped, will eventually enable definite production recommendations to be made in order to guarantee uniformity of texture between different makes or specimens. One of the most potent factors in achieving uniformity is the method of wheel dressing, but this is also the most difficult to specify. Until experimental work is completed, this new standard will be useful in ensuring accuracy and in distinguishing between specimens produced by natural grinding and the " freak " specimens produced by what is termed pseudo grinding. These latter specimens are usually produced by varying feed and traverse or by induced vibration or " chatter " and while the accuracy requirements may be without fault in terms of C.L.A. assessment, the textures often consist of dominant machining marks of known depth and spacing which cannot usefully be compared with the natural ground surface of a work piece.

OIL SUCTION AND DISCHARGE HOSE WITH BUILT-IN END CONNECTIONS FOR TEST PRESSURES OF 100 LB, 150 LB, 200 LB AND 225 LB PER SQUARE INCH

No. 1435 : 1960. Price 7s. 6d. Requirements for lightweight hose, not included in previous editions of this Standard, are given in this revised edition, as well as requirements for rough and smooth bore hose for dock and submarine service. The types of oil suction and discharge hose specified are those commonly used for transferring liquid petroleum products to and from tankers and bunkering vessels. Details of hose construction have been less rigidly defined than in previous editions, as it is felt that such detailed specifications might hamper the introduction of improved materials or methods of construction. A further change is that no reference is made to the hose working pressure ; instead, hose is classified by factory test pressure and it is left to the user to determine the appropriate working pressure.

The test requirements have been altered in some respects ; in particular, the hydrostatic pressure to be applied in the production sample test has been increased from three to four times the factory test pressure for finished hose. In addition, hose previously rated at a working pressure of 250 lb per square inch has been reduced to a factory test pressure of 225 lb per square inch and a new criterion of hose elongation has been introduced.

GEAR HOBS PART 2 : HOBS FOR GEARS FOR TURBINE REDUCTION AND SIMILAR DRIVES

No. 2062 : Part 2 : 1960. Price 10s. Basic dimensions for hobs required for the production of gears for turbine reduction and similar drives are now recommended for the first time in Part 2 of B.S. 2062, which has just been revised. It has not been possible to achieve complete agreement on the dimensions but recommended dimensions are given for these tooth forms and pitches listed in B.S. 1807 : Part 2 (which relates to gears for turbines). These dimensions are suitable for the larger hobbing machines used in this type of work. Recommended arbor dimensions are also included to ensure correct fit between hob and arbor. As in the previous edition, accuracy requirements are laid down. The permissible errors given are similar to those in the previous edition but the layout of the table has been improved to make it comparable with Part 1 of the standard, a revision of which was published in 1959.

THE USE OF COLD FORMED STEEL SECTIONS IN BUILDING

Addendum No. 1 (1961) to No. 449 : 1959. Price 7s. 6d. The use of steel sections cold formed from plate, sheet and strip steel is now firmly established in steelwork construction and this publication on the subject will be of particular interest to the steelwork industry as a whole. The Technical Committee which prepared it made use of valuable information contained in technical papers and pamphlets based on research and published in the U.K., the U.S.A. and European countries.

In addendum, for use in conjunction with B.S. 449, " The use of structural steel in building," care has been taken to indicate in the text those clauses of B.S.449 which apply to the use of cold-formed sections and those which do not. Supplementary information is given regarding materials, design and details of construction, and tests for use in the approval of welders. Included in an appendix are examples of design calculations.

A companion standard to the addendum is B.S.2994, " Cold rolled steel sections," which sets out properties of a number of basic shapes in common use. The methods of design set out in Addendum No. 1, however, apply also to other cold-formed shapes that may be required to meet special structural conditions.

CYLINDER BORE SIZES FOR INTERNAL COMBUSTION ENGINES

No. 3386 : 1961. Price 4s. The object of this new British Standard is to establish a range of cylinder bore sizes for new designs of internal combustion engines which will facilitate a reduction in the number of variants of cylinder liners and piston rings. The standard specifies requirements for cylinder bore sizes from 1in (25·4mm) diameter to 12in (304·8mm) diameter for both two-stroke and four-stroke cycle, spark-ignition and combustion-ignition engines (excluding aircraft engines). These requirements include nominal bore sizes, tolerances and increments of oversizes, which are set out in four tables.

CLASS II METAL-ARC WELDING OF STEEL PIPELINES AND PIPE ASSEMBLIES FOR CARRYING FLUIDS

No. 2971 : 1961. Price 12s. 6d. This is the fourth in a series of standards being issued to cover the production of welds in pipelines and pipe assemblies of any material used sufficiently widely to warrant its inclusion. It covers shop and site metal-arc welding of joints in carbon steel pipelines and pipe assemblies up to and including 24in (610mm) diameter carrying fluids suitable for Class II conditions and also the standards of workmanship of which the welders shall be capable and the standards to which the welds shall conform. It deals with butt welding, with or without a backing ring, where the welding is done from the outside only, and the welding of gusseted bends, sleeve joints, branches and flanges.

SILICONE-RUBBER-INSULATED CABLES AND FLEXIBLE CORDS

No. 3258 : 1960. Price 5s. This standard has been prepared in view of the increasing use of silicone-rubber-insulated cables and flexible cords. It covers a range of these cables and cords in conductor sizes up to 0·06 square inch suitable for a maximum conductor operating temperature of 150 deg. Cent. The specification takes the same general form as other British Standards for rubber-insulated cables, but is confined to single-core, twin and three-core cables and cords finished either with glass braid and silicone varnish, or with asbestos braid and heat-resisting compound. The usual tests are included, with an additional heat-cycle test for single-core glass-braided flexible cords only.

BUTT-WELDED, SINGLE POINT CUTTING TOOLS AND BLANKS

No. 1296 : 1961. Price 6s. In this revised standard the shapes of the working ends of lathe, planer and shaper tools are illustrated and related to a standard series of fifteen tool shank sections. In addition to covering general purpose tools the standard now covers special purpose tools, and a schedule of tool shapes which have particular applications, such as internal recessing, has been added.

Each tool shape is numbered, to assist both purchaser and supplier, and information on corresponding inch/metric sizes of tool shanks, as agreed internationally, is given in an appendix to the specification.